MARS SURVEYOR OPERATIONS PROJECT

READINESS REVIEW - PART I

August 26-27, 1998

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

MARS SURVEYOR OPERATIONS PROJECT READINESS REVIEW - PART I

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JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

Mars Surveyor Operations

AGENDA

Wednesday, August 26, 1998

8:00	Welcome, Introduction, and scope of review	Cunningham
8:10	Status of MGS, MPL, MCO and Stardust	Beerer McNamee Duxbury
8:25	MSOP Schedule 8/26/98 - 3/1/99	Cunningham
8:40	MSOP Organizational Structure, Shared Team Approach, Resiliency	Cunningham
8:55	Previous Action Item Status	Cunningham
	Flight Operations Overview:	
9:10	MGS Aerobraking Phase 2	Beerer
9:50	Mars Climate Orbiter and Mars Polar Lander	Thurman
11:50	Stardust (Data system issues only)	Duxbury
12:30	Lunch	

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AGENDA

Wednesday, August 26, 1998

1:30	Mission Development and Support Readiness	Jai Lopez Theisinger
3:30	TMOD Support Readiness for Mars and Stardust	McKinney
4:30	Review Board Discussion of first day results	Ploszaj

Mars Surveyor Operations

AGENDA

Thursday, August 27, 1998

8:00	Operations Test and Training Overview	Brower
8:15	Spacecraft Team Readiness	Neuman
	Readiness for MGS A/B 2	Starnes
	Readiness for MCO, MPL	Dukes
10:15	Navigation Team Readiness	Esposito
11:45	Lunch	
12:45	Mission Planning and Sequence Team	Brooks
1:15	Science Office	Thorpe
1:45	MGS Special Topic: HGA Deployment Issues	Whetsel
2:30	Risk Assessment	Whetsel
3:00	Summary of Open Issues	Cunningham
3:15	Readiness Statement	Cunningham
3:20	Board Meeting	Ploszaj

Mars Surveyor Operations

AGENDA

Friday, October 30, 1998

8:00	Welcome, Introduction, Scope of Today's Review	Cunningham
8:10	Closure of Previous Open Issues	Cunningham
9:15	MCO, MPL Status Update	Thurman
9:30	MOS Compatibility Testing and Validation for '98	Whetsel, Lopez
10:30	Mission Development and Support	Theisinger, Lopez, et al
12:00	Lunch	
1:00	Science Facility Readiness	Thorpe, et al
1:30	Operations Test and Training for '98	Brower
2:45	MSOP Launch / Hold Criteria	Whetsel
3:00	Media Relations and Outreach	Cunningham, Goodall
3:15	Summary of Open Issues	Cunningham
3:30	Readiness Statement	Cunningham
3:35	Board Meeting	Ploszaj

Mars Surveyor Operations

REVIEW BOARD

Richard A. Cook
John McNamee
Richard W. Zurek
Al Schallenmuller
Patricia Klein
Ronald A. Ploszaj
Arden Albee
Bill Piotrowski
James M. Stewart
Paul Ondrus
John R. Casani
Richard C. Coffin
Ken Atkins
Robert M. Manning
Bill O'Neil
Tom Coughlin
Gail Robinson
Frank Palluconi

Mars Surveyor Operations

SCOPE OF REVIEW

REVIEW OBJECTIVE:

Establish that the MARS SURVEYOR OPERATIONS PROJECT is ready to support:

- **the second phase of Mars Global Surveyor aerobraking,**
- **launch and early cruise (through second TCM) of the MSP'98 spacecraft, and**
- **the launch (ground data system support) of the Stardust mission.**

SCOPE OF THE REVIEW

SUCCESS CRITERIA:

This review will be considered successful if all readiness preparations are considered complete, required and committed capabilities are in place and verified, and any open items can reasonably be expected to be resolved by the time the capability is required.

- **GDS capabilities required will be complete by launch or beginning of MGS aerobraking phase 2 as appropriate**
- **Operations organizations and facilities are in place and staffed**
- **Operations implementation, MOS compatibility verifications, test and training will be complete before launch or beginning of MGS aerobraking phase 2 as appropriate**
- **All previous related action items, liens, etc.. have been closed or will be before launch or beginning of MGS aerobraking phase 2 as appropriate**

Mars Surveyor Operations

ROADMAP TO THE REVIEW

- **EARLIER THAN NORMAL FOR THIS TYPE OF READINESS REVIEW**
  - **ACCOMMODATES START OF MGS A/B 2 (9/14/98)**
  - **ACCOMMODATES MCO AND MPL TEST PROGRAM AND SCIENCE OPS CENTER READINESS (PART II ON 10/30/98)**
    - **MGS AEROBRAKING PHASE 2 THROUGH ABX (2/9/99)**
    - **MCO, MPL LAUNCH THROUGH MPL TCM 2 (2/15/99)**
    - **STARDUST LAUNCH AND CRUISE GDS SUPPORT**

Mars Surveyor Operations

ROADMAP TO THE REVIEW

- **PART I**
  - **FIRST DAY (Today)**
    - **GENERAL BACKGROUND INFORMATION**
      - **SCOPE**
      - **MISSION STATUS**
      - **OVERALL INTEGRATED SCHEDULE**
      - **CORE OPERATIONS APPROACH**
      - **ACTION ITEM STATUS**
    - **UP-FRONT ISSUES**
    - **OPERATIONS ISSUES FOR EACH MISSION**
      - **MGS**
      - **MCO, MPL**
      - **STARDUST**
    - **CORE CAPABILITIES READINESS**
      - **CORE DEVELOPMENT AND SUPPORT READINESS**
      - **TMOD SUPPORT READINESS**

ROADMAP TO THE REVIEW

- **PART I**
  - **SECOND DAY (Tomorrow)**
    - **TEST AND TRAINING PLANS FOR MCO, MPL LAUNCHES**
    - **FLIGHT TEAM READINESS**
      - **SPACECRAFT**
      - **NAVIGATION**
      - **MISSION PLANNING AND SEQUENCING**
      - **SCIENCE OFFICE/TEAMS**
    - **MGS HGA DEPLOYMENT ISSUE**
    - **RISK ASSESSMENT**
    - **READINESS STATEMENT FOR:**
      - **CORE SYSTEMS**
      - **STARDUST GDS SUPPORT**
      - **MGS AEROBRAKING**
      - **MCO, MPL TEST AND TRAINING**
      - **MCO, MPL MOS COMPATIBILITY**

Mars Surveyor Operations

ROADMAP TO THE REVIEW

- **PART II (Friday, October 30, 1998)**
  - **BACKGROUND AND STATUS INFORMATION**
    - **ACTION ITEM CLOSURE**
    - **MISSION STATUS UPDATE**
  - **MCO, MPL MISSION COMPATIBILITY TESTING RESULTS**
  - **MISSION DEVELOPMENT AND SUPPORT UPDATE**
  - **SCIENCE OPERATIONS FACILITY READINESS**
  - **MCO, MPL TEST AND TRAINING STATUS**
  - **MSOP LAUNCH AND HOLD CRITERIA**
  - **MEDIA RELATIONS**
  - **READINESS STATEMENT FOR:**
    - **MCO, MPL LAUNCH AND EARLY CRUISE**

NEXT REVIEWS

• MGS MAPPING READINESS	2/3/99
• M'01 ATLO SUPPORT READINESS	7/14/99
• MCO MOI AND A/B READINESS	7/15-16/99
• MPL LANDING READINESS	10/5-6/99
• M'01 LAUNCH AND CRUISE READINESS	1/5/01
• MCO MAPPING READINESS	2/1/01
• M'01 MOI AND A/B READINESS	10/1/01
• M'01 LANDING READINESS	11/1/01

MGS Flight Status

J. G. Beerer

Mars Surveyor Operations

MGS Flight Status

- Operating in Science Phasing Orbit
  - 11.6 Hour Period, 170 km Periapsis Altitude
- Executing Week-long Science Sequences
  - Daily Playbacks of Science Data
- MOLA Was Turned Off in Late July
  - MOLA Warming Maneuver Performed Once Per Orbit
- Two Phobos Observations Were Very Successful
  - Two More Planned: 8/31 and 9/12
- No Spacecraft Health Issues
  - Except HGA Deployment Schedule
- SAM Yoke Shows No Sign of Degradation
  - Hinge Angle Check Shows No Change

Mars Surveyor Operations

MGS Flight Status

- Phase 2 Aerobraking ORTs Are Complete
- Preparations for Aerobraking Are Complete
  - Except for Minor ABGEN & SEQGEN Fixes
- Spacecraft Memory Buffer Reallocation on 9/10/98
  - Enlarges Sequence Buffer for 18 AB Orbits
- Aerobraking Resumes on 9/14/98
- Propellant Budget Adequate for Full Mapping Mission
  - Fine Tuning of AACS Parameters for Drag Pass Has Enabled Staying Within Budget While Sequencing Multiple AB Orbits

Flight Operations Overview

Backup Charts

J. G. Beerer

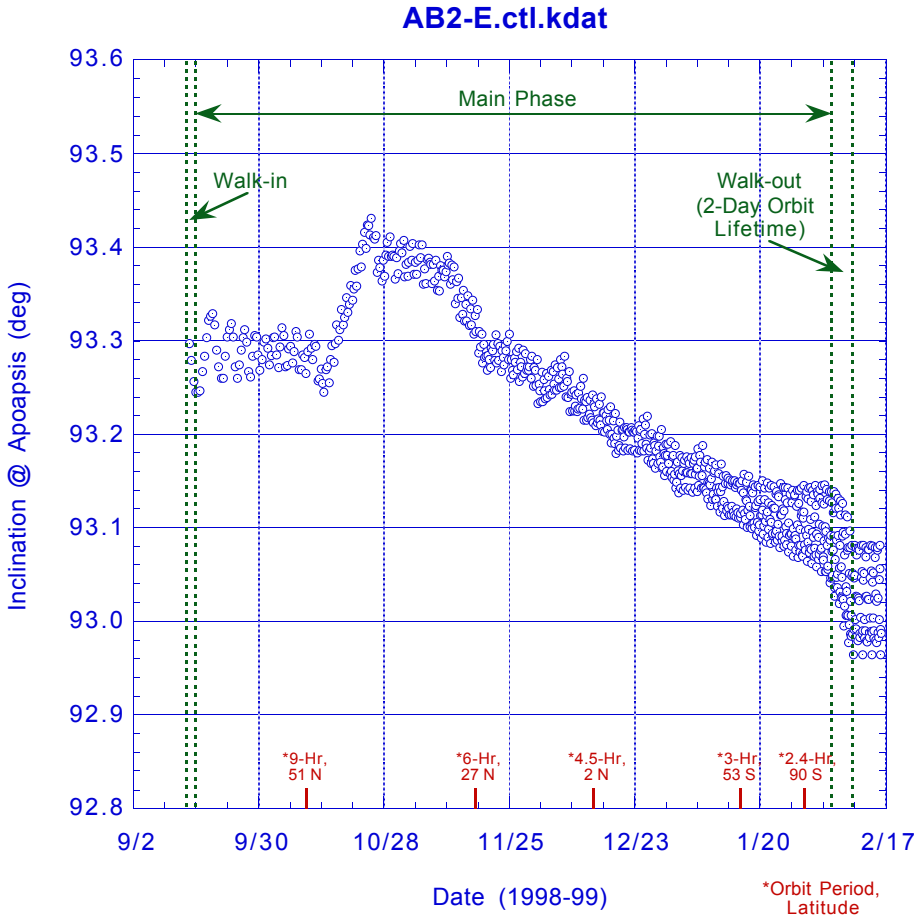
Mars Surveyor Operations

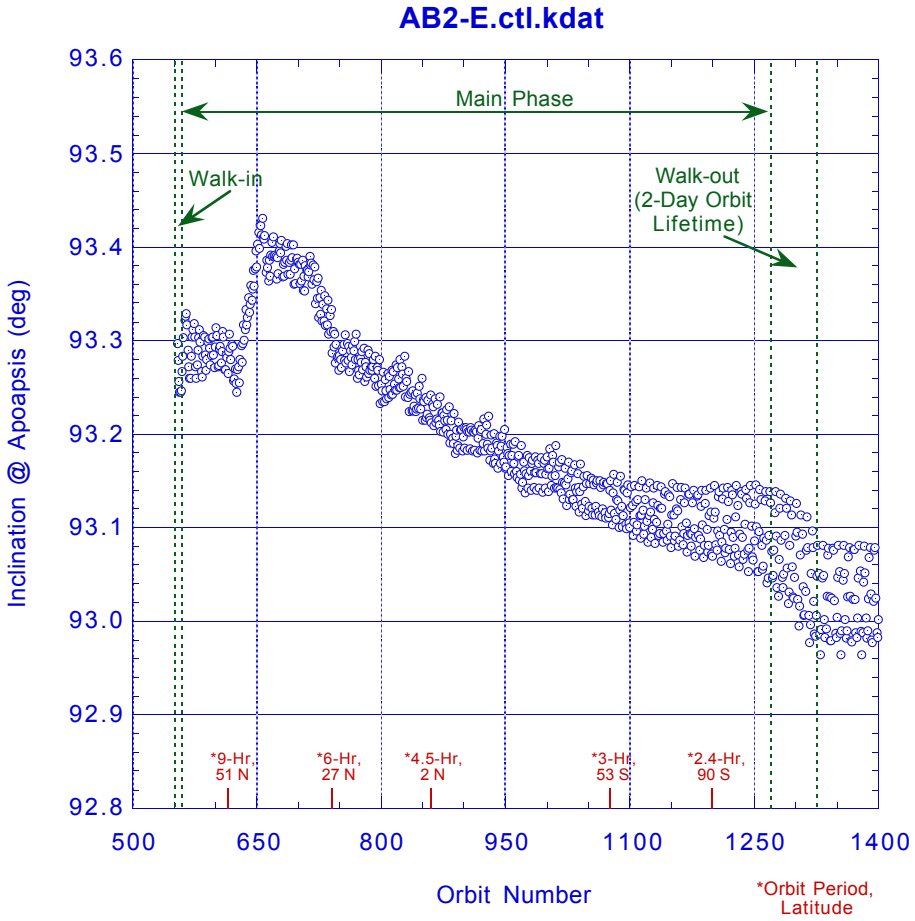
Flight Profile Summary

	Baseline (Jun '98)		
AB Phase 2 Initiation	Date	Orbit	Lat
Start Date (AB-1)	14-Sep-98	554	61.3
Walk-in Duration	1.45	3	-
Main Phase	Date	Orbit	Lat
Established	16-Sep-98	557	60.9
Main Phase Duration	141.74	711	-
9-Hr Orbit Period	10-Oct-98	615	51.0
6-Hr Orbit Period	17-Nov-98	740	27.3
4.5-Hr Orbit Period	13-Dec-98	860	1.5
3-Hr Orbit Period	15-Jan-99	1075	-52.5
Walk-Out (Ha=~900 km)	Date	Orbit	Lat
Start Date	04-Feb-99	1268	-67.7
Walk-out Duration	4.51	56	-
ABX-2	09-Feb-99	1324	-51.7
Total Duration	147.70	770	-

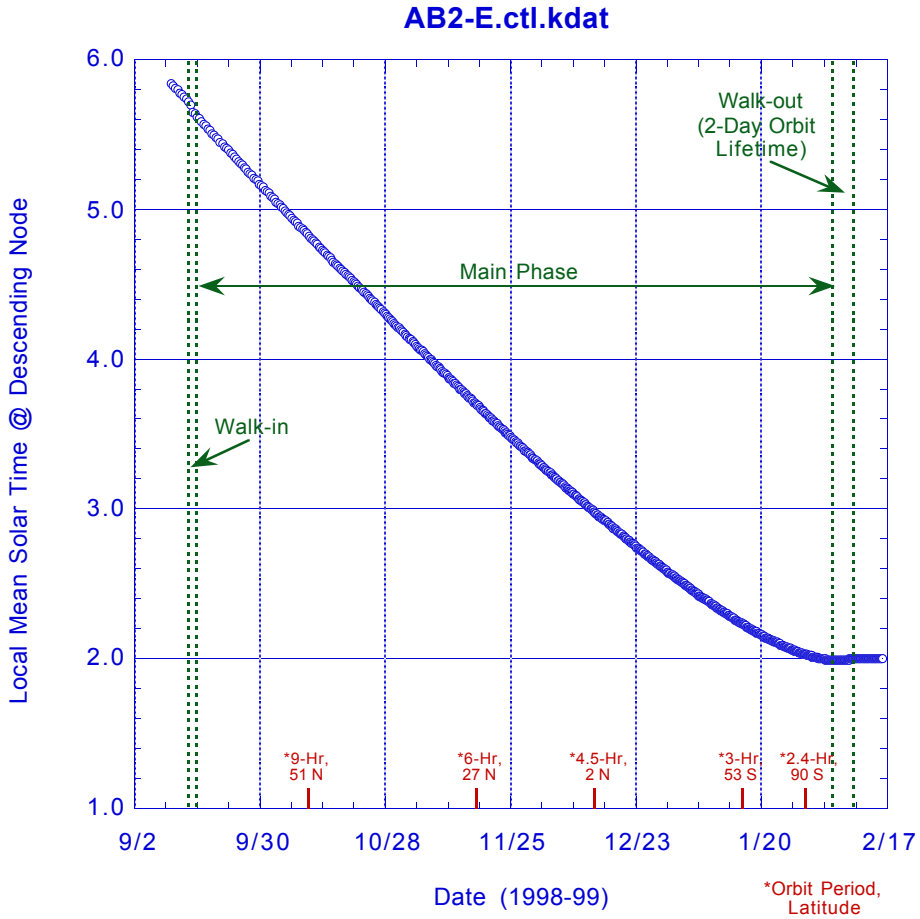
	Baseline (Jun '98)	
Local Mean Solar Time (Desc Node)		
AB Phase 2 Initiation	5.62	5:37 AM
ABX-2	2.00	2:00 AM
Orbit Inclination	Osc	Mean
AB Phase2 Inititation (pre-AB-1 @ Apo)	93.764	93.767
AB Phase2 Inititation (post AB-1 @ Apo)	93.297	93.300
ABX-2 (Periapsis)	92.987	
Req'd Mapping Orbit Inc (Periapsis)	92.978	
Main Phase Dynamic Pressure Corridor		
1. 11.6 Hr < Period < Walk-out	0.135 < q < 0.235	
Ave Dynamic Pressure	0.178 (249 Orbits)	
2. 5.0 Hr < Period < Walk-out	0.085 < q < 0.185	
Ave Dynamic Pressure	0.133 (462 Orbits)	
3. Profile Average	0.149 (711 Orbits)	
ΔV Summary	ΔV	No.
AB-1 (Biprop)	12.02	1
Walk-in	1.5	2
Main Phase	7.7	17
Walk-out	2.7	3
Total ΔV (Monopropellant)	11.9	22
Occultations		
Occulations Start	21-Nov-98	(Orbit 756)
Max Occultation Duration (min)	69.9	
Occulations End	N/A	
Eclipses		
Eclipses Start	31-Dec-98	(Orbit 965)
Max Eclipse Duration (min)	39.1	
Eclipses End	N/A	

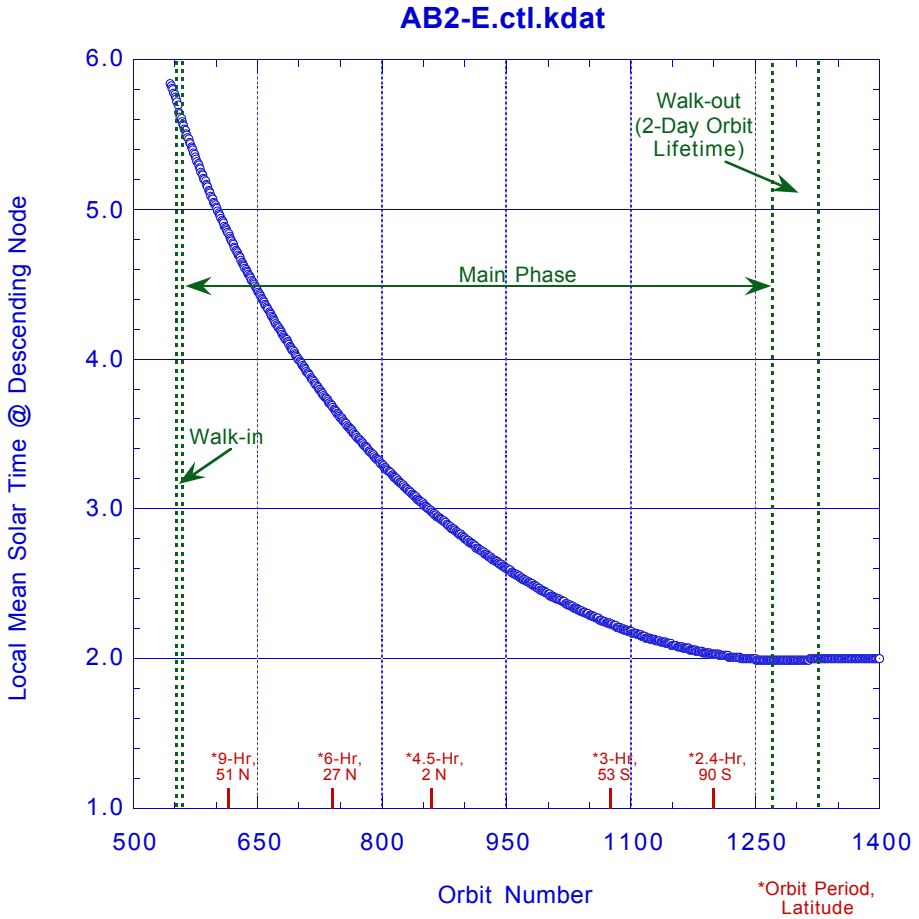
Orbit Inclination



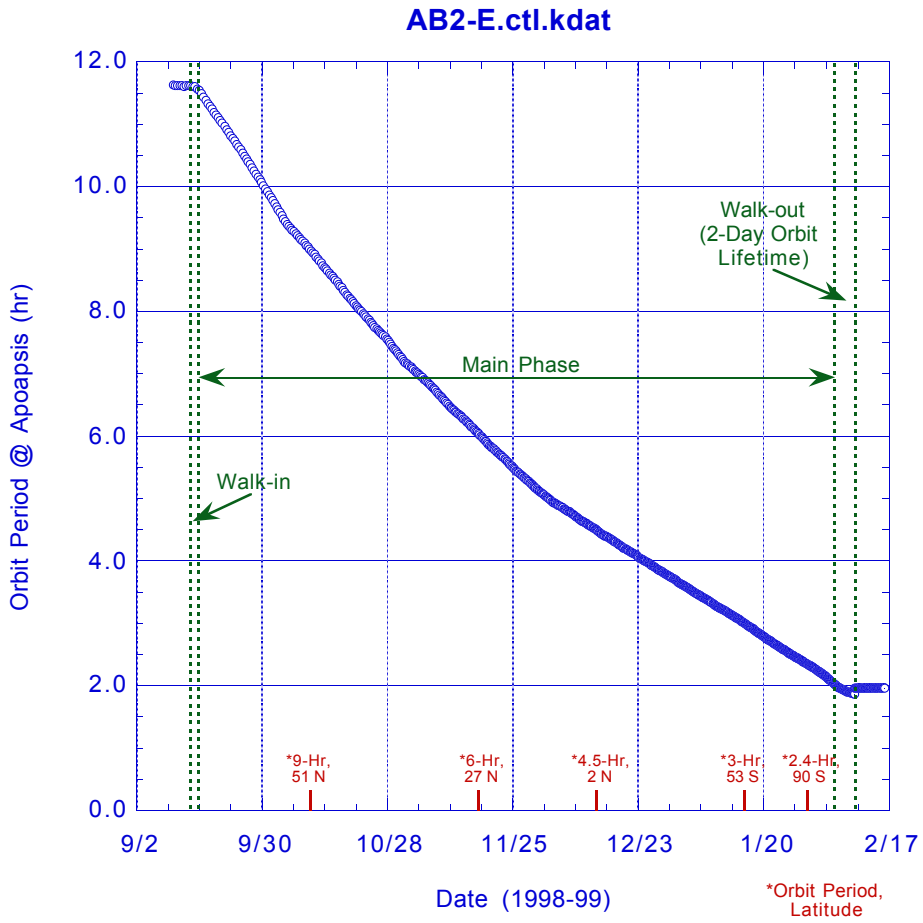


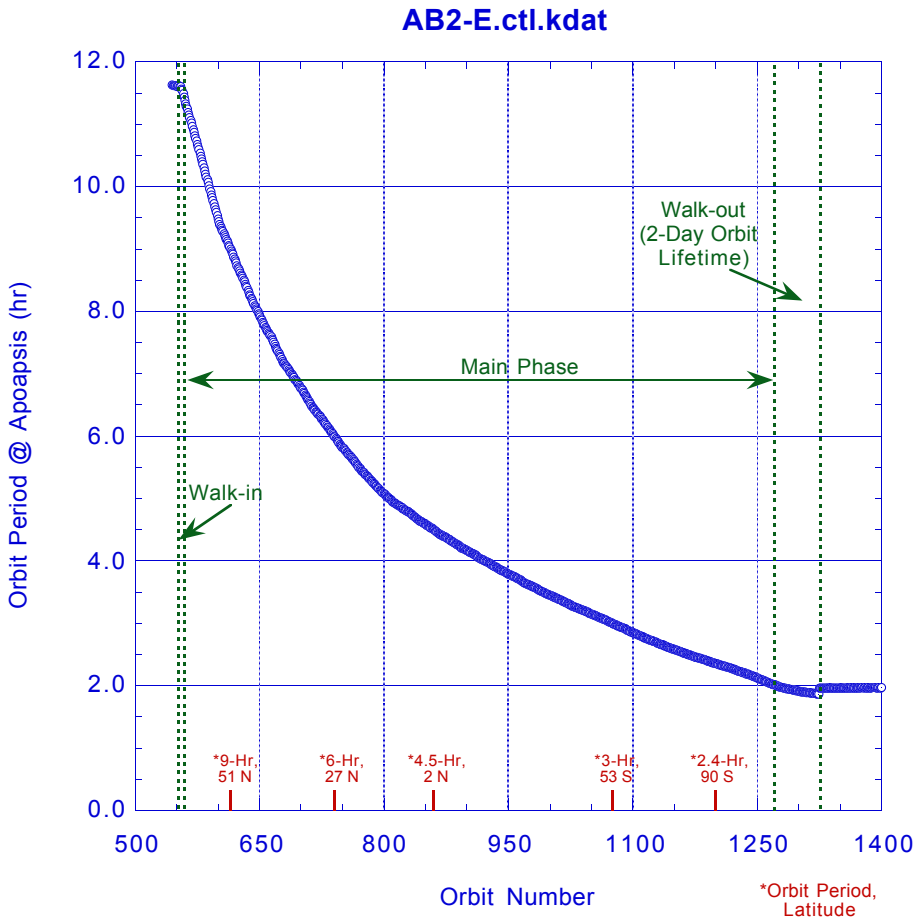
Local Mean Solar Time (LMST)



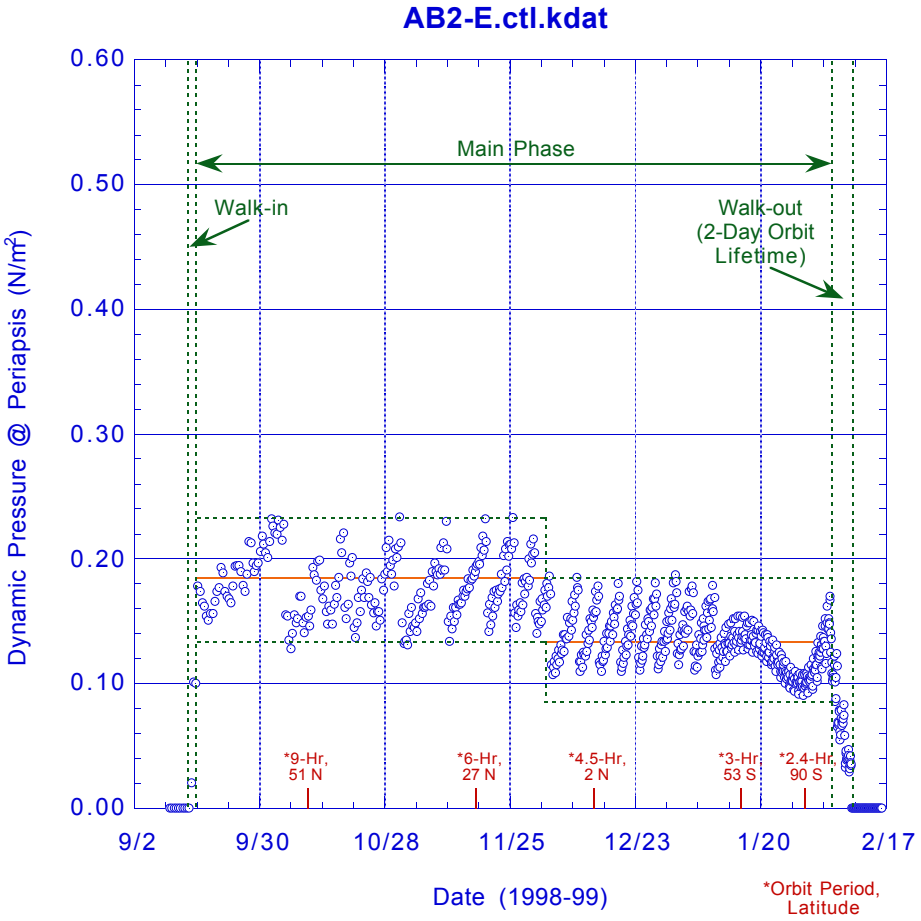


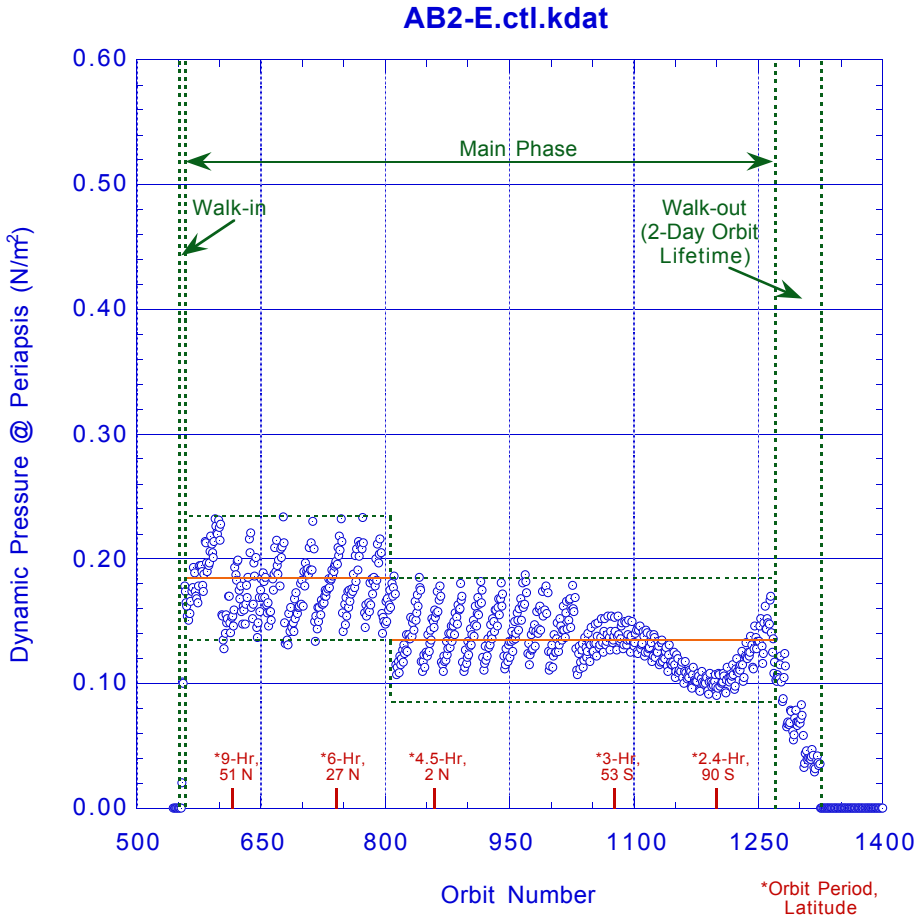
Orbit Period



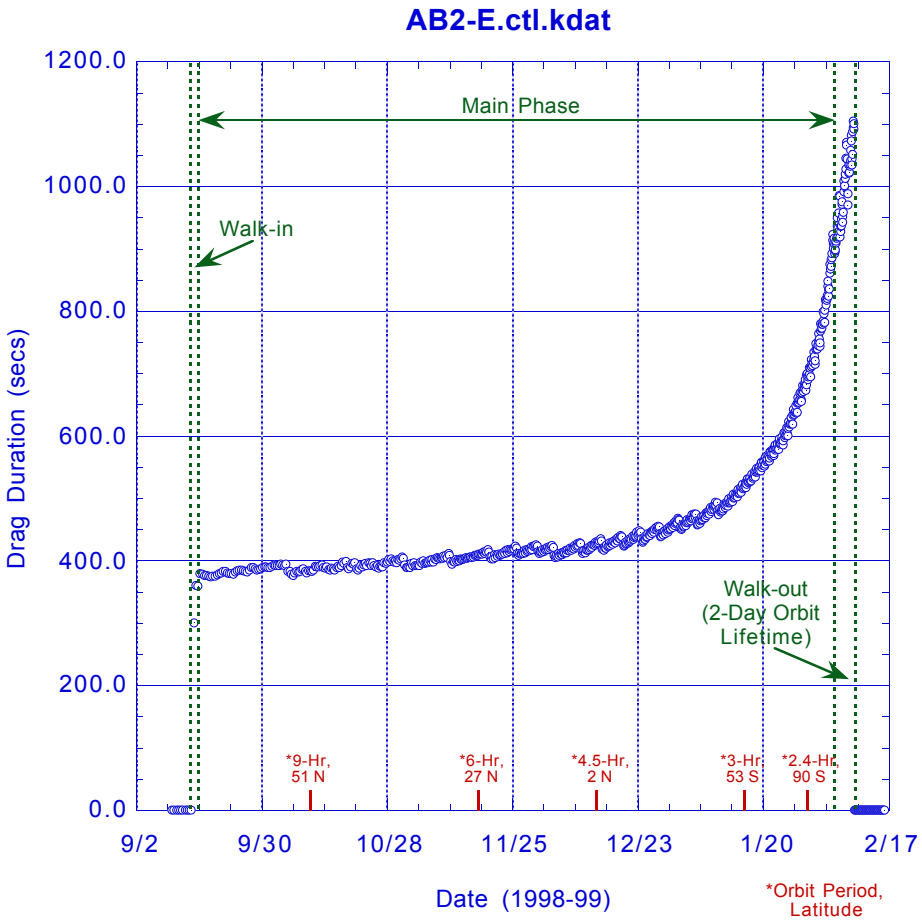


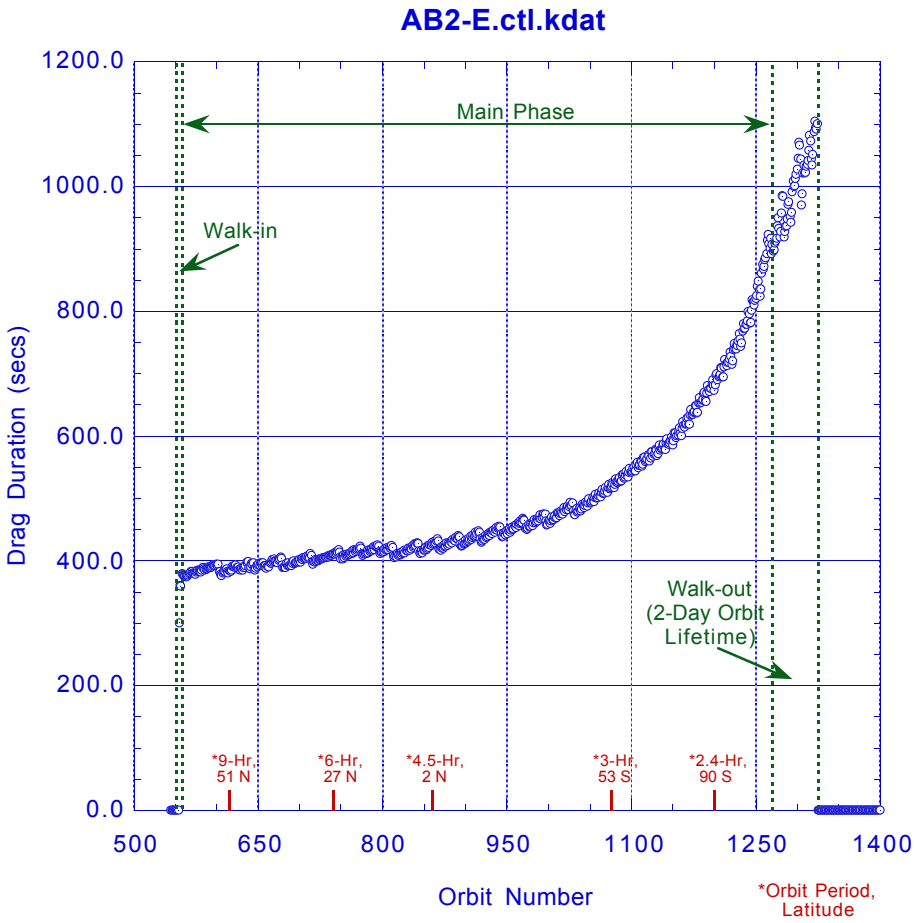
Dynamic Pressure



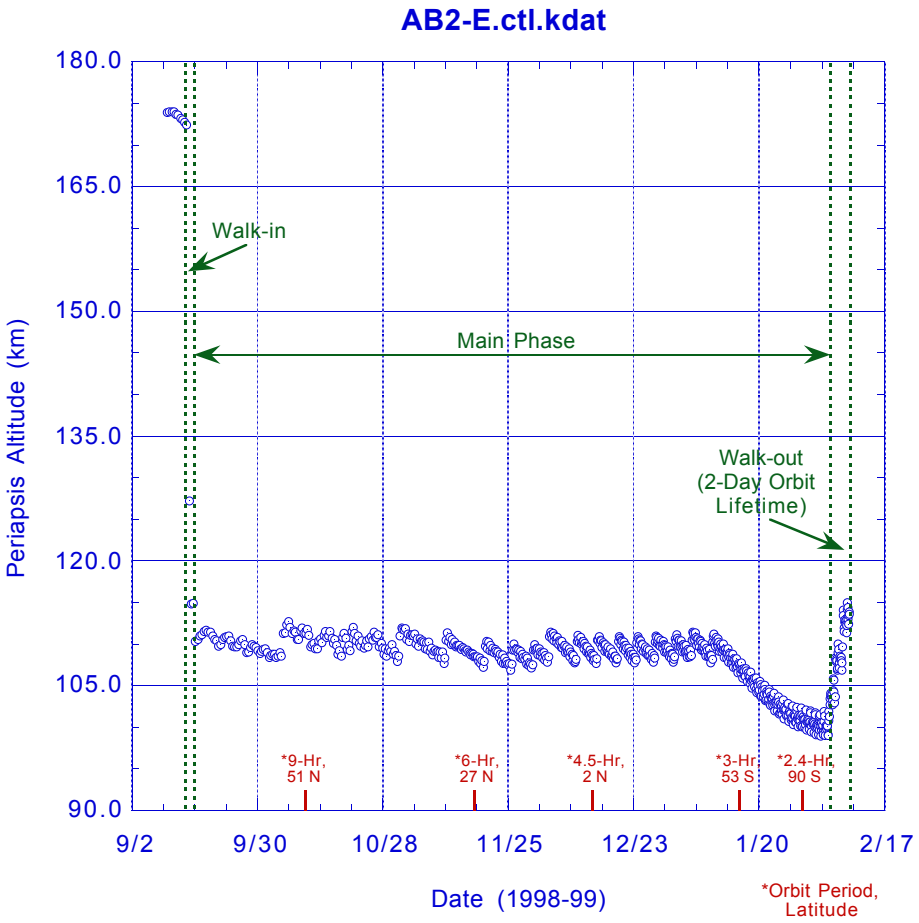


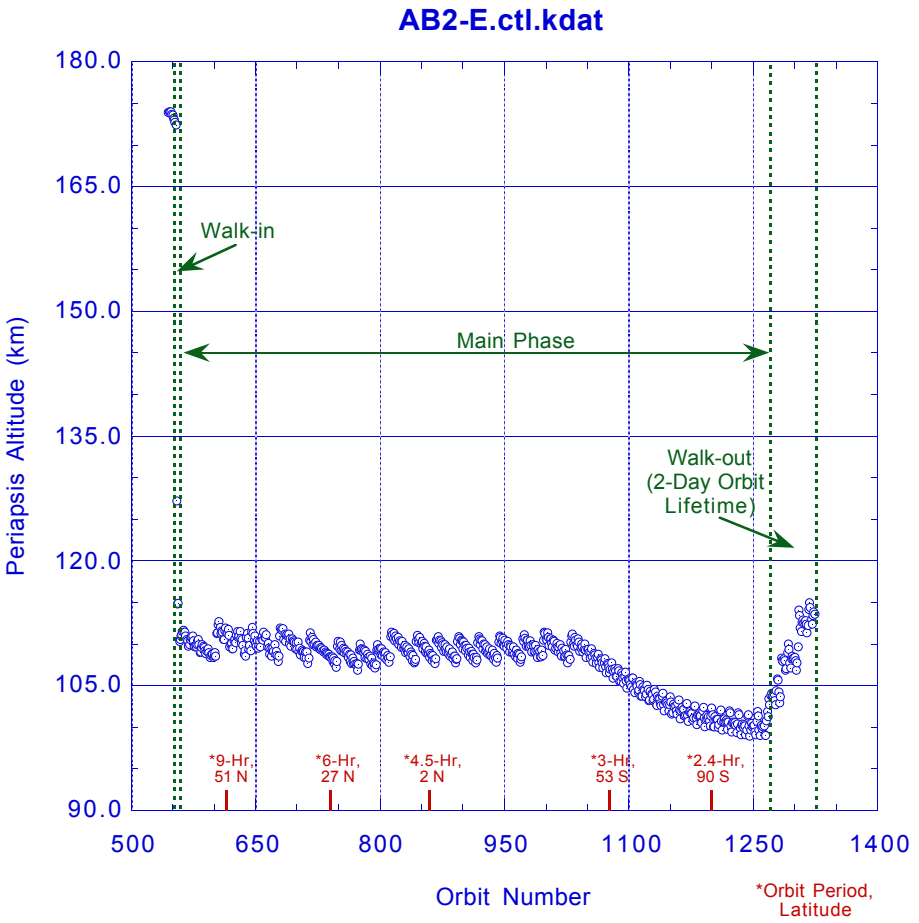
Drag Duration



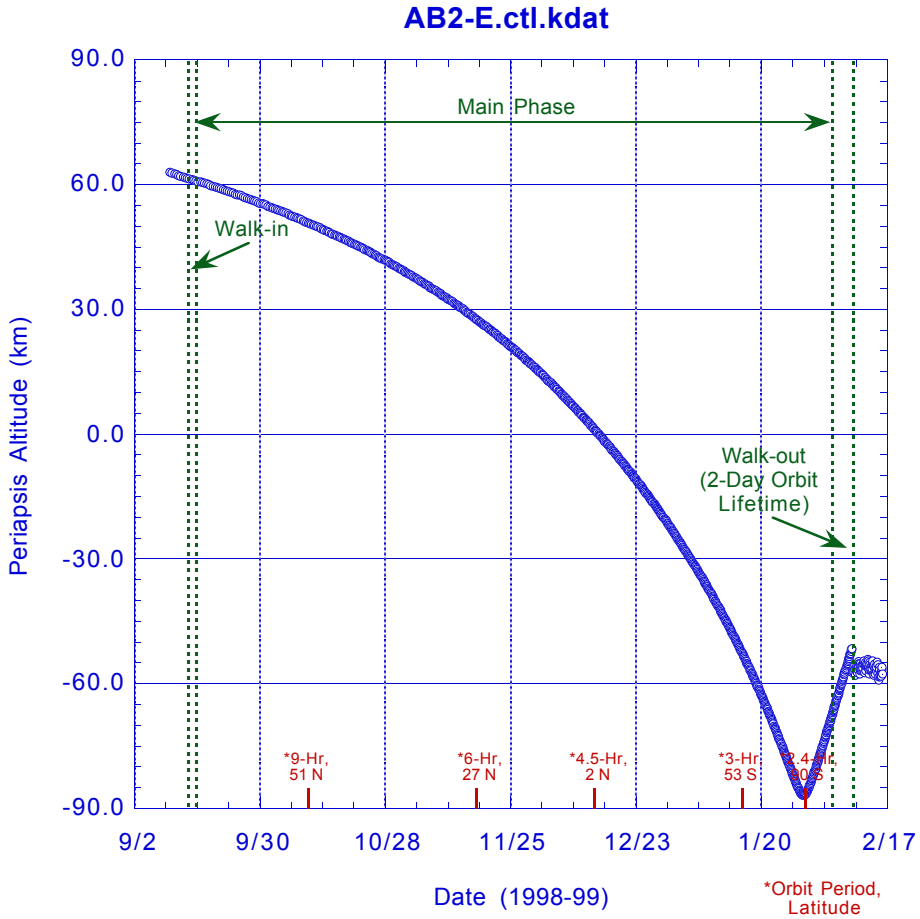


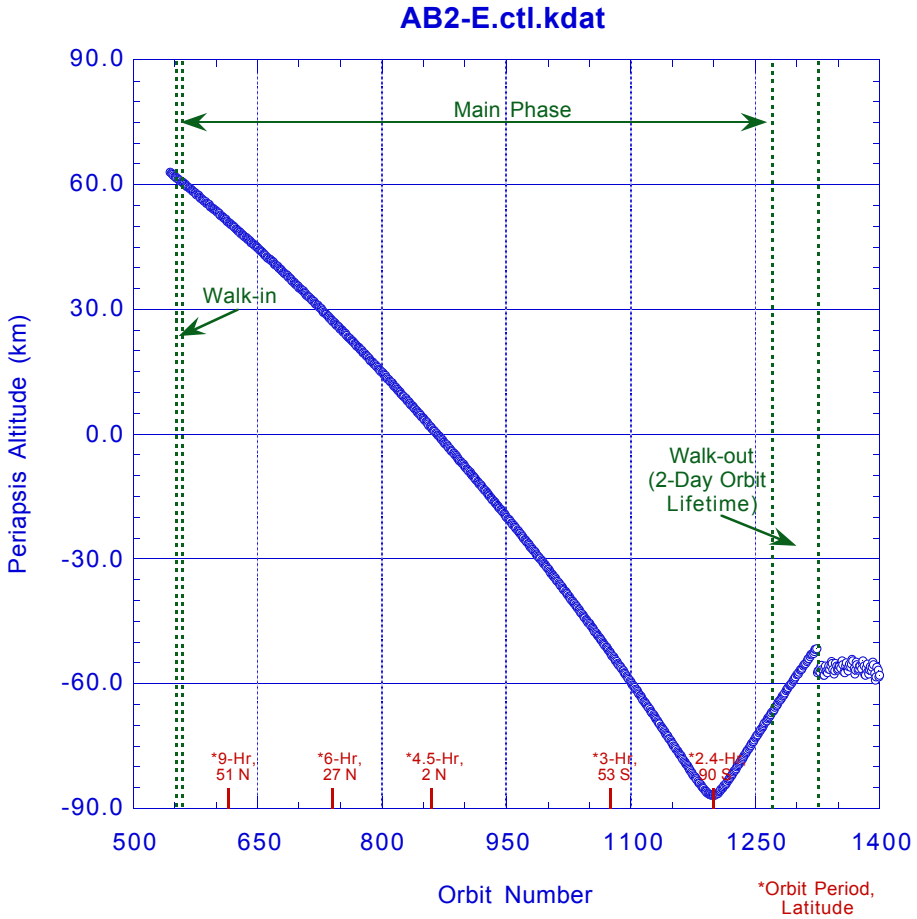
Periapsis Altitude



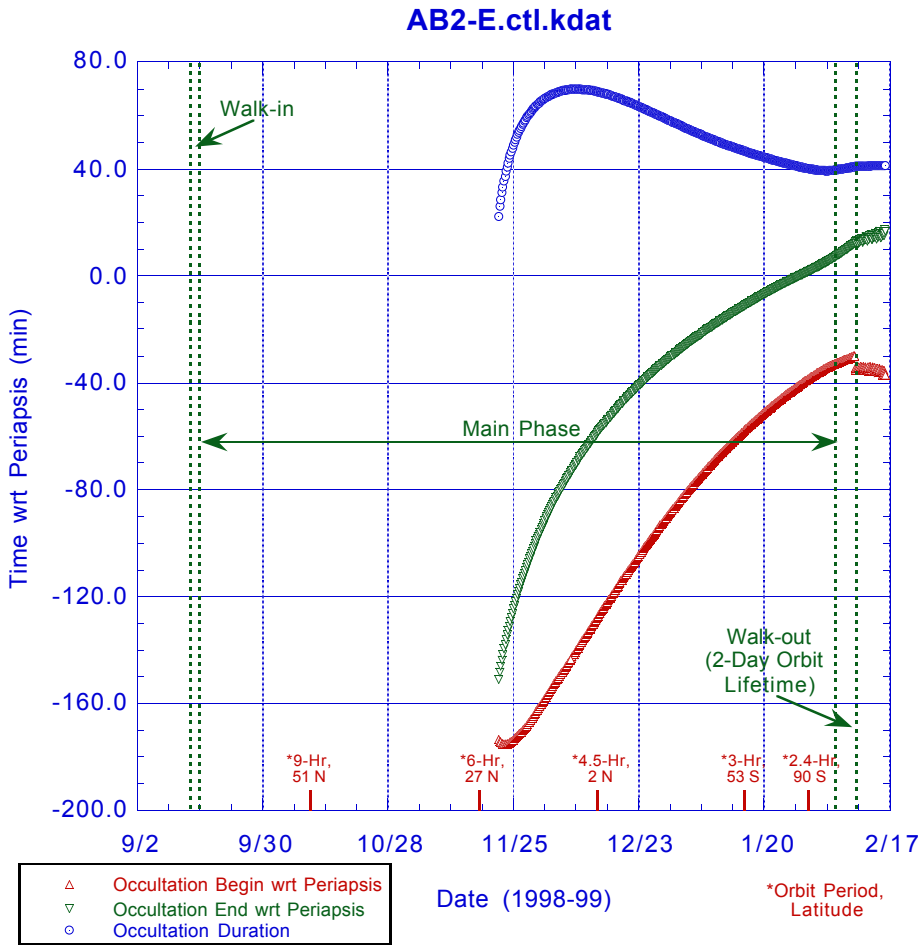


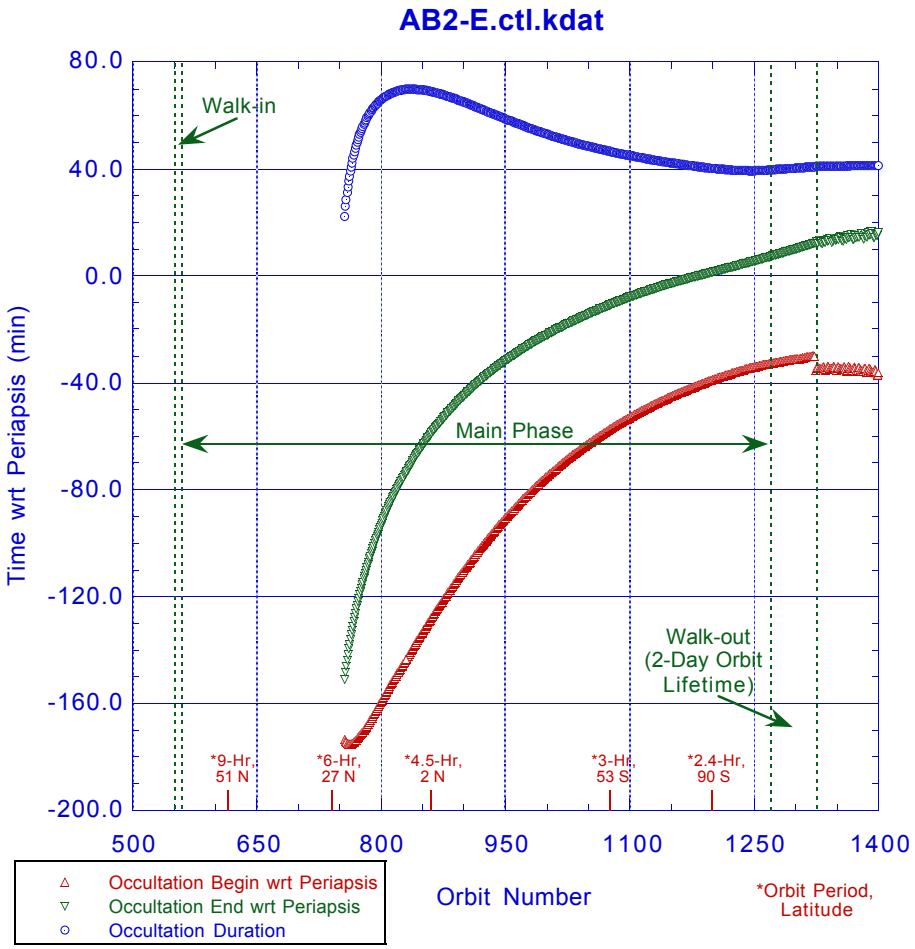
Periapsis Latitude



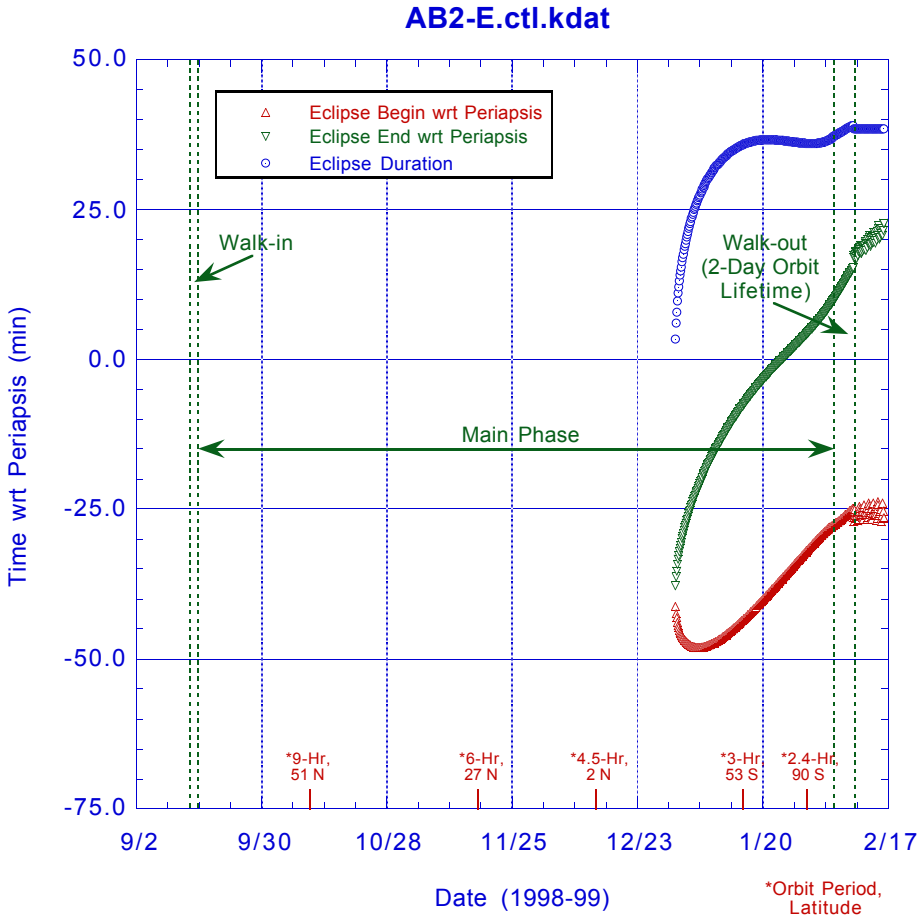


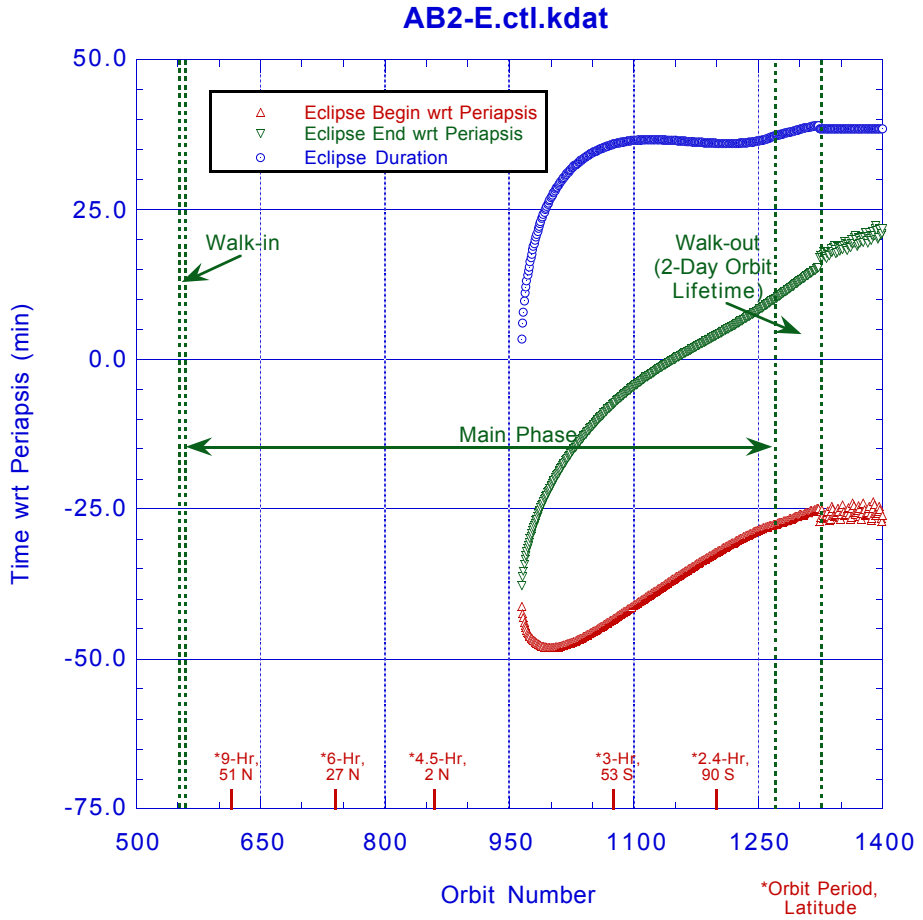
Occultation Entry / Exit wrt Periapsis



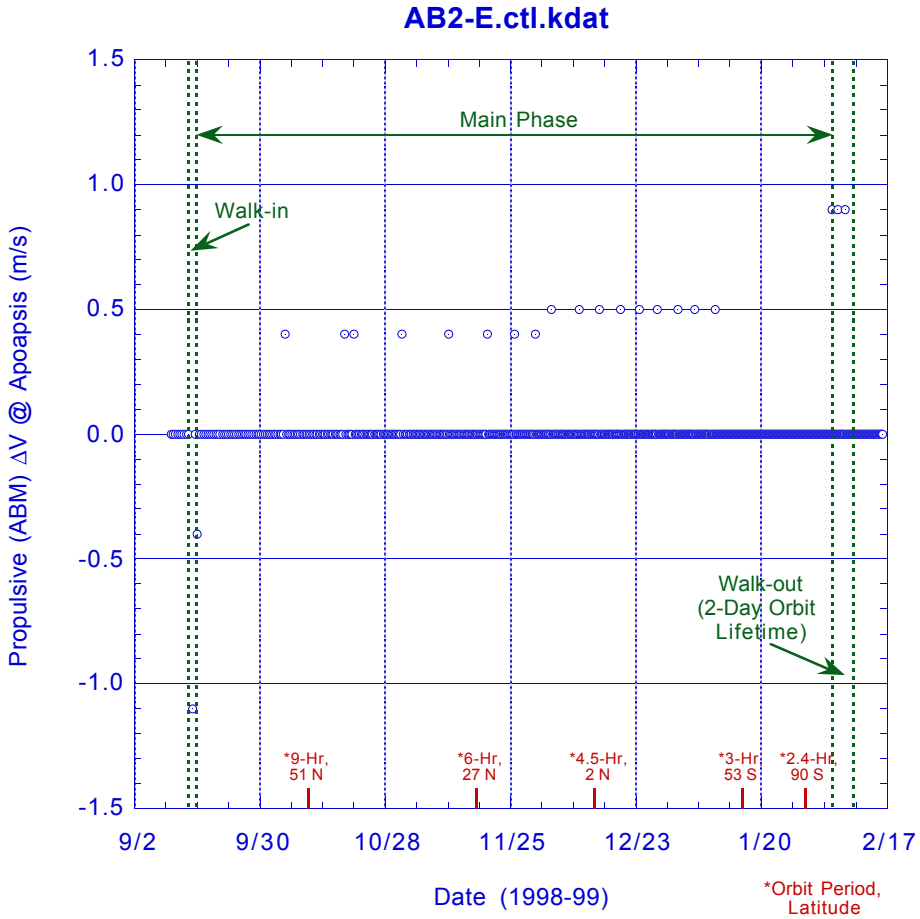


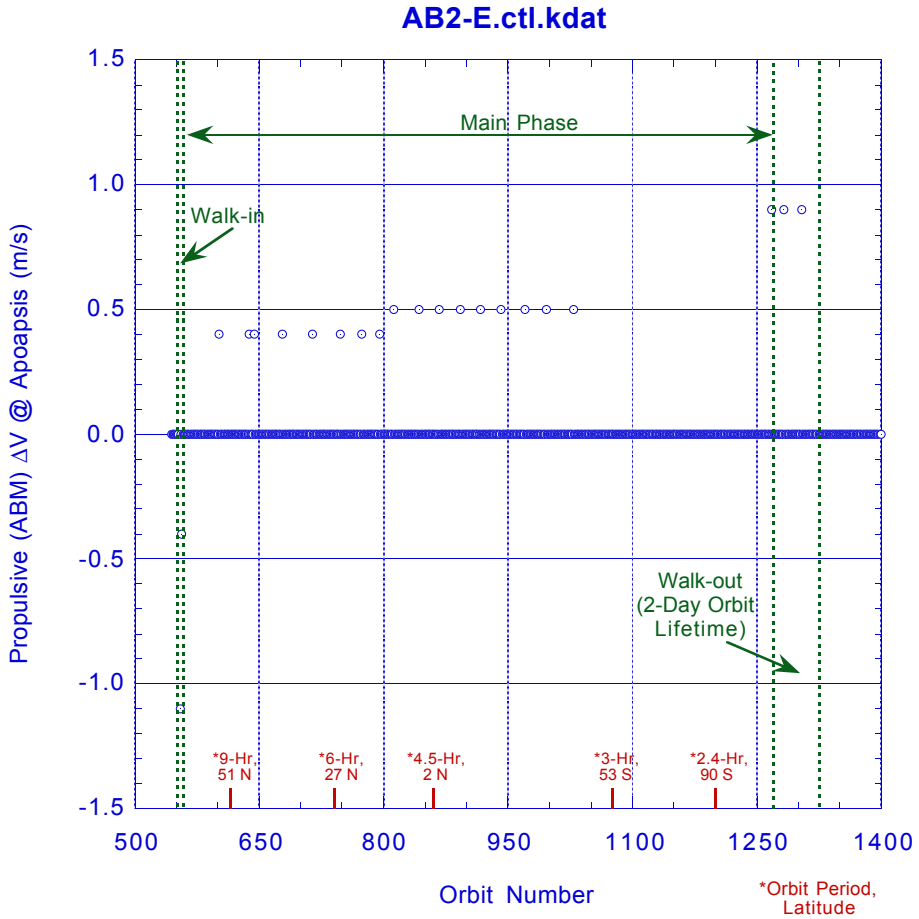
Eclipse Entry / Exit wrt Periapsis





ABM (Propulsive) ΔV





STATUS OF
MARS POLAR LANDER
&
MARS CLIMATE ORBITER

John McNamee

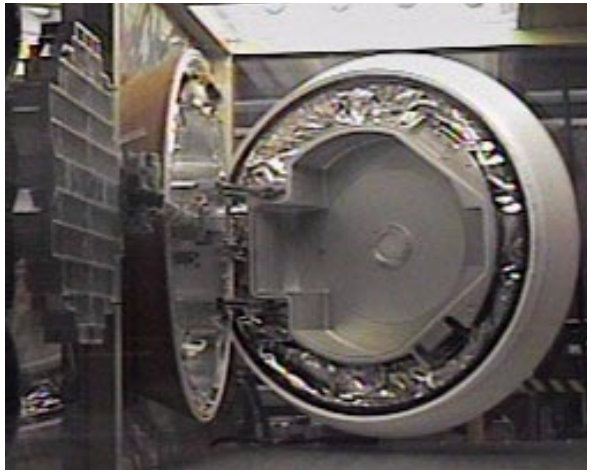
STATUS OF STARDUST
NASA Discovery Comet Sample Return Mission

Thomas C. Duxbury
STARDUST Mission Manager
&
MGS MOLA Science Team Member

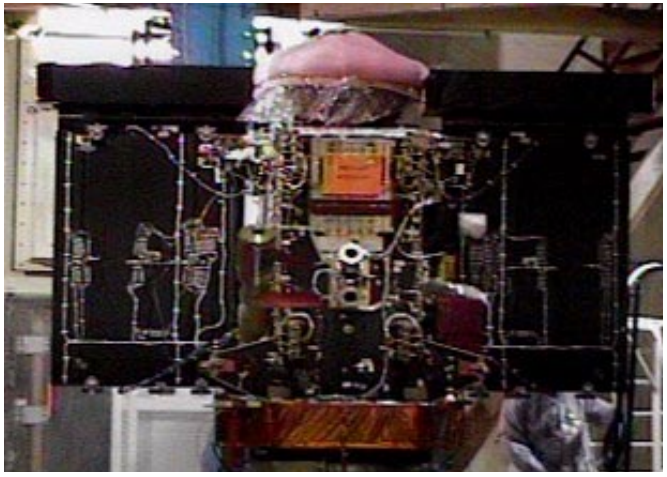
STATUS OF STARDUST

- **Spacecraft with Sample Return Capsule in Environmental Testing**
  - **End-to-end Testing of Payload in STL Successfully Completed Early this Year using MSOP-provided GDS**
  - **DSN and MOS Compatibility Testing Successfully Completed using MSOP-provided GDS**
  - **Completed Spacecraft and Sample Return Capsule Fabrication**
  - **End-to-end Spacecraft Performance Test #1 Successfully Completed using MSOP-provided GDS**
    - **Launch, Despin, S/A Deploy, Comm, TCM Blocks**
  - **Successfully Completed Acoustical Testing**
  - **End-to-end Spacecraft Performance Test #2 being Completed using MSOP-provided GDS**
    - **SPT #1 + Collector Deploy, SRC Separation, Encounter, Return Blocks**

SRC Drop Test at UTTR



SRC Collector Deploy



RAL for Frequency Survey & Acoustics

Mars Surveyor Operations

STARDUST NEAR-TERM ACTIVITIES

- **Studying Coating on Solar Array Diodes**
  - **Thermal Cycling caused Cracking**
- **Studying Cracked Glass Bodied Diodes**
  - **expect to go with current state**
- **Complete Environmental Testing in Oct**
  - **SPT #3 including Fault Protection / Fail Safe Modes & Blocks using Launch Version of GDS provided by MSOP**
- **Ship to Cape 11 Nov 1999**
- **Launch 6 Feb 1999**

Mars Surveyor Operations

STARDUST RESOURCE STATUS

- 5 kg Mass Margin with Filled Tanks
  - Will add Ballast to Delta 3rd Stage
- 50 % Power Margin at P/Wild 2
  - 19 % Power Margin at Aphelion
- Downlink, CPU Throughput, DRAM Memory, EEPROM Memory, etc. have Good Margins
- 15 Days of Pre-ship Schedule Margin
  - 7 additional days with Sundays and Holidays
- 20 Days of Schedule Margin at KSC
  - 26 additional days with Sundays and Holidays
- Funding Reserves Sufficient to add 20+ FTE's thru Launch
- MSOP-provided GDS continues to be Ahead of Needs
- Feel Comfortable about making Launch

INTEGRATED SCHEDULE

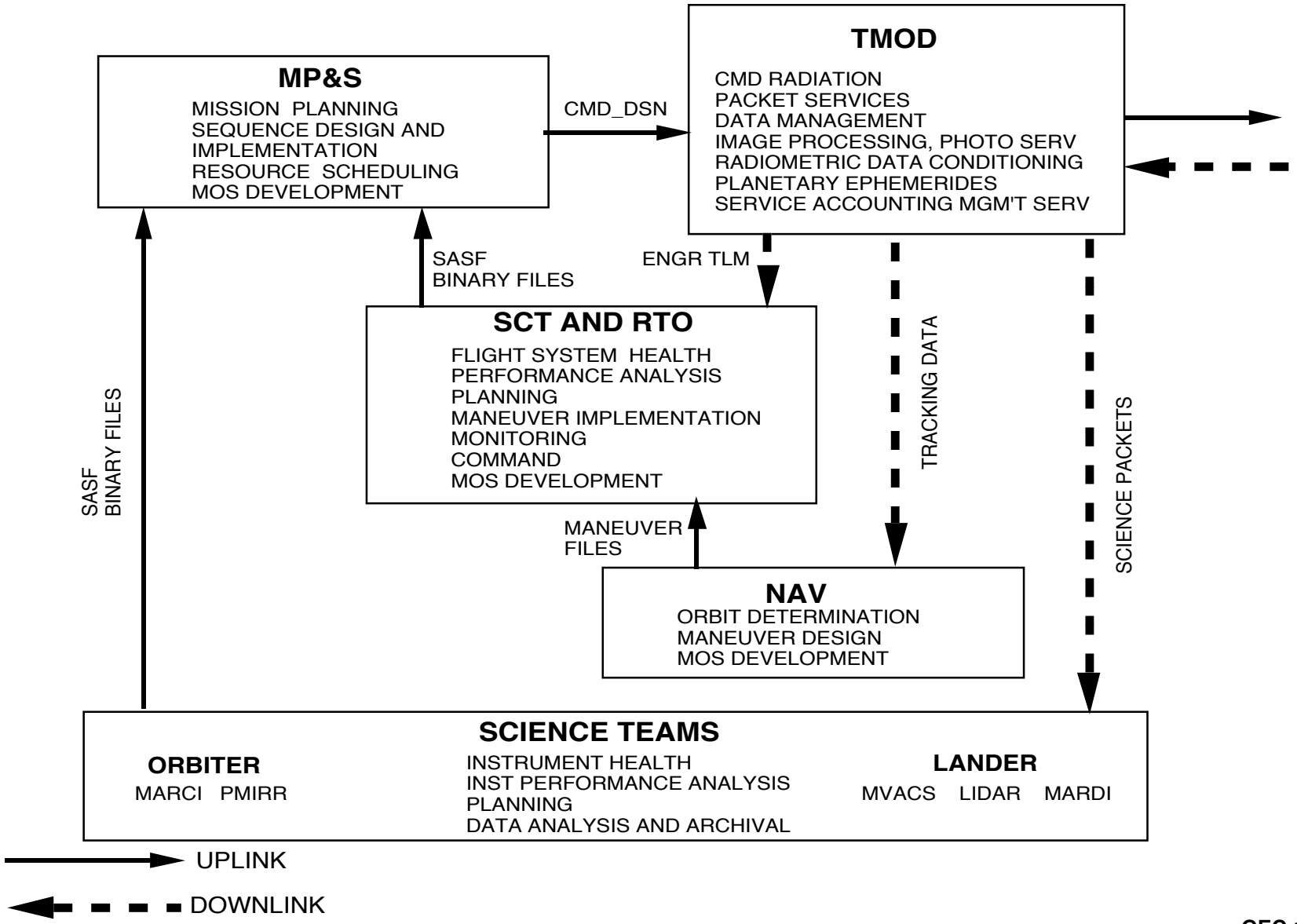
ITS ON THE WALL

Mars Surveyor Operations

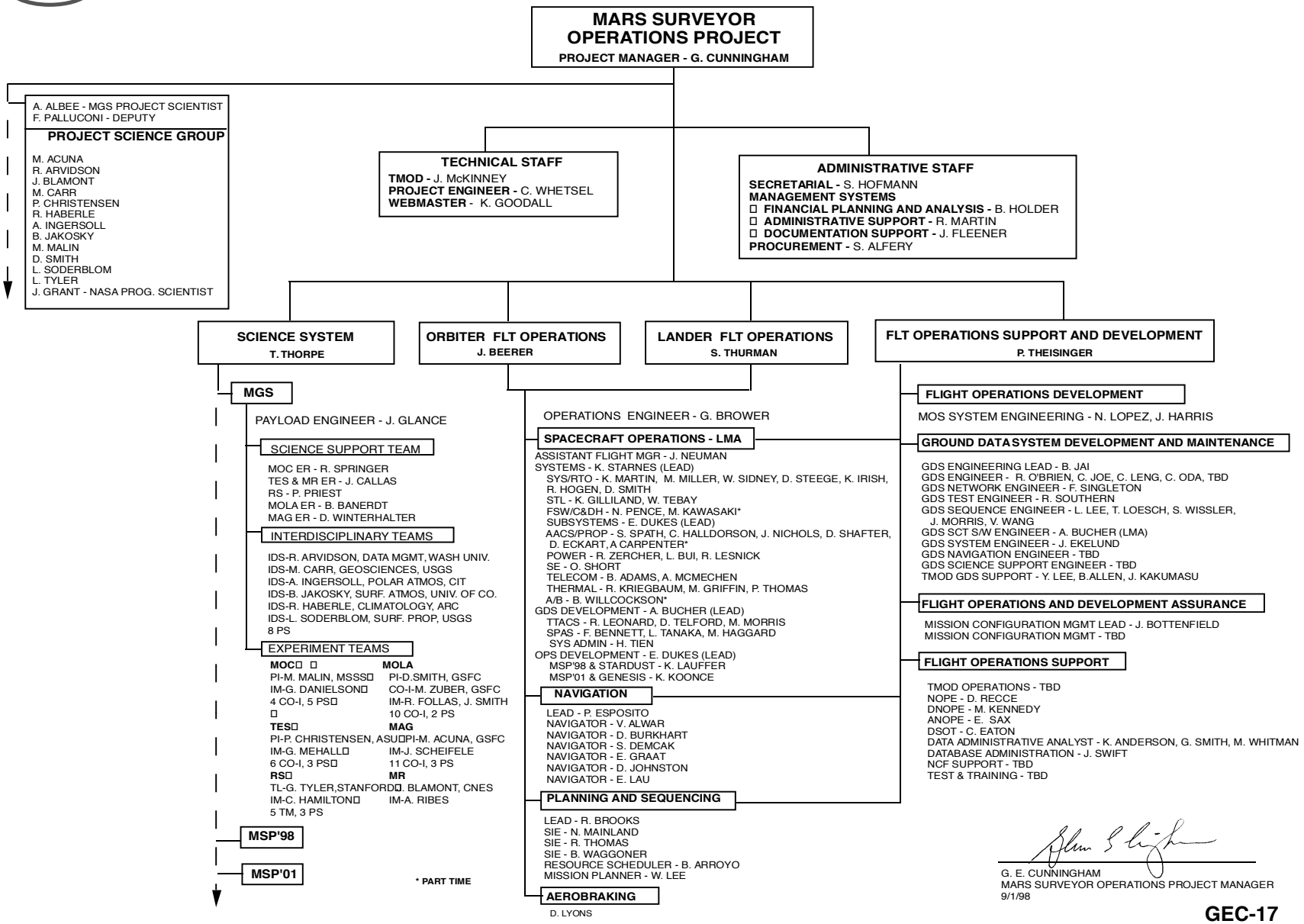
MSOP STRUCTURE

- **OPERATES SURVEYOR MISSIONS AFTER LAUNCH**
  - **READINESS TO OPERATE (MGS, MCO, MPL)**
- **PROVIDES GROUND DATA SYSTEMS TO OTHER CUSTOMERS**
  - **READINESS TO SUPPORT STARDUST**
- **SHARED PERSONNEL - DEVELOPMENT AND OPERATIONS**
  - **KEY TO LOW COST OPERATIONS**
- **COMMON OPERATIONS TEAMS SUPPORT EACH MISSION**
  - **REAL TIME OPERATIONS**
  - **SPACECRAFT**
  - **NAVIGATION**
  - **MISSION PLANNING AND SEQUENCING**

MSOP FUNCTIONAL ORGANIZATION



MSOP ORGANIZATION



G. E. CUNNINGHAM
MARS SURVEYOR OPERATIONS PROJECT MANAGER
9/1/98

RESILIENCY

- **CAREFUL SCHEDULING TO AVOID OVERLAPPING EVENTS IN NORMAL OPERATIONS**
  - **DEFERRAL OF NON-CRITICAL EVENTS IF OVERLAPS OCCUR DUE TO UNFORESEEN CIRCUMSTANCES**
- **BACKUP FUNCTIONAL CAPABILITIES - JPL AND LMA**
  - **RTO OPERATES TWO SPACECRAFT SIMULTANEOUSLY**
  - **SEQUENCING CAPABILITIES AT BOTH LOCATIONS**
  - **COMMANDING CAPABILITIES AT BOTH LOCATIONS**
  - **LIMITED SPACECRAFT HEALTH MONITORING AT JPL**
- **EMERGENCY CONTROL CENTER AT GOLDSTONE**
  - **NAVIGATION**
- **BACKUP PERSONNEL LIST (DEVELOPMENT PERSONNEL)**
  - **SIGNIFICANT ANOMALY SUPPORT**
  - **EXAMPLES**
    - **MGS SOLAR ARRAY YOKE FAULT AND MISSION REDESIGN**
    - **MGS HGA DEPLOYMENT ISSUE**
- **MANAGEMENT**
  - **PROJECT MANAGER AND PROJECT ENGINEER SERVE AS BACK-UP FLIGHT OPERATIONS MANAGERS**

Ground System Contingency Plans

- **ASP at JPL Goes Down**
  - **ASP Now On-line At LMA**
  - **SCT Members Are Trained In Its Use**
- **LMA MSA Goes Down**
  - **Whetsel & Brower Are Certified DEUCES (Command from JPL)**
  - **Telemetry Monitoring From JPL??**
- **Communications Line Outage Between JPL and LMA**
  - **Procedures In Place to More Quickly Restore Capability**
- **JPL Out of Service Due to Earthquake**
  - **Move DSOT and Command Central to ECC**
  - **Move Nav Operations to ECC**
  - **Move Sequence Operations to LMA**

Mars Surveyor Operations

PREVIOUS ACTION ITEM STATUS

CDR ACTION ITEM NO.	CATEGORY	ACTION ITEM	ASSIGNED TO	STATUS
			DUE DATE	
CDR-1	Integrated Schedule	Develop an integrated MSOP development schedule which includes operations activities and continues through MSP'98 arrival and landed operations.	P. Theisinger 10/1/97	Closed
CDR-2	Resiliency	Institute a process to identify potential anomalies/ problems and develop contingency plans as appropriate to cover the suite of operational scenarios with acceptable risk and resource impact.	N. Lopez 4/1/98	Closed
CDR-3	Science Adjudication	Develop a process for the adjudication of science / mission return conflicts between the missions being operated by MSOP	G. Cunningham 6/1/98	Closed
CDR-4	Surface Operations Complexity	Develop a lander baseline operations plan which has resiliency to ground, Mars environmental, lander or MGS induced problems. Incorporate Pathfinder experiences, and lessons learned in the plan development.	N. Lopez P. Knocke 2/1/98	Closed
CDR-5	STL Availability	Develop a integrated MSP'98 / MSOP / SD plan for STL availability / usage which includes MSP'98 development (FSW and ATLO), Stardust development (FSW and ATLO), sequence generation (ATLO and flight), MOS compatibility objectives, and test and training.	K. McNeil 1/1/98	Development: Closed; ORT Support: Open until 9/7/98
CDR-6	Validation, Test and Training	Accelerate development of MOS validation and test and training planning. Integrate the test and training with ATLO system testing activities.	N. Lopez 4/1/98	Plan development: Closed; Implementation scheduling: Open until 8/31/98

Mars Surveyor Operations

PREVIOUS ACTION ITEM STATUS

CDR ACTION ITEM NO.	CATEGORY	ACTION ITEM	ASSIGNED TO	STATUS
			DUE DATE	
CDR-7	TMOD Delivery Scheduling	Develop with TMOD an integrated long term schedule for the delivery of (1) TMOD core capability, and (2) TMOD updates and modifications, which factor in MSOP operations limitations and funding constraints.	P. Theisinger 12/1/97	Closed
Delta CDR-1	Operational Readiness Testing	Conduct a 24-48 hour operations simulation test with MSOP personnel of short period aerobraking orbits during the SPO period using any new processes or ground data system elements to be in place in aerobraking phase 2 that might also benefit MSP'98 A/B.	Beerer: Plan 6/1/98; Test; <8/26/98	Closed
Delta CDR-2	MGS HGA Deployment	Review plans for HGA deployment and determine if MGS HGA deployment process should be modified and/or if there should be any changes to the mapping mission, or mission contingency plans.	Whetsel 7/1/98	Open
Delta CDR-3	Anomaly Support	Determine how a small, broadly trained, contingency support team could be established that would be assigned to field anomalies during critical periods of multiple spacecraft support.	Beerer Thurman 8/26/98	Closed
Delta CDR-4	Specific Spacecraft Operational Teams	Examine MSOP staffing plans and challenge the MSOP philosophy of broad capability team with the notion of special teams for each spacecraft supported within the MSOP cost constraints.	Starnes Brooks Esposito	Closed
Delta CDT-5	MGS Planetary Protection	In relation to the 20 year planetary protection requirement, direct work to providing sufficient probability to meet the requirement, and if not possible, prepare a waiver based on Mars Pathfinder cruise stage similarities.	Barengoltz	Closed

Mars Surveyor Operations

ACTION ITEM CLOSURE DETAILS

- **CDR-1**

Various forms of integrated schedules used since review

- **CDR-2**

Our process for contingency planning is that this is one of the jobs done for each mission event/phase by the cross-disciplinary teams we've formed to develop operations plans and procedures.

Each team is responsible developing the detailed timeline, sequences, and procedures, including contingency plans, sequences, and procedures, for their mission phase. We have formed teams for the launch transition to cruise, midcourse maneuver, and MARCI Earth/Moon cal events and will form additional teams in a timely manner for the later mission events/phases.

In addition to this general process, we formed a special team which was active from Oct. '97 through Jun. '98 to rework our operational plan and onboard sequence blocks for the early portion of the MPL surface mission. This team addressed action items 2 and 4 together for this mission phase.

- **CDR-3**

Objective to operate all missions to ALL requirements. MSOP Project Manager adjudicates issues of conflict

If decision violates a requirement of one or more of the supported missions, or if Manager cannot reach a decision, then:

Mission Adjudication Group (Project Scientists, MED Chief Scientist, Director of MED) renders judgment or directs alternative solution. MSOP is bound to comply. (IOM GEC:490-98-40.1)

- **CDR-4**

The special mission design team mentioned in item 2 above reworked and expanded the baseline surface mission operations plan to incorporate resiliency to environmental uncertainty and potential ground, MCO, and MPL problems. Lessons learned from both the MPF surface mission and MGS phase-1 aerobraking were incorporated. These changes were documented in MS '98 ECR-081, which was approved on 26 Jun 98.

Mars Surveyor Operations

ACTION ITEM CLOSURE DETAILS

- **CDR-5**

The issue raised here was the need for a plan that accommodated the completion of MS '98 and Stardust ATLO and S/W development, ops test and training, and flight ops support. Since Aug '97, the MS '98 Project developed a second test system in the STL; Stardust has their own dedicated system. We have forwarded our planned ORT schedule and request for STL time in support of test and training to the '98 team. In flight, the current plan calls for one of the two '98 STL systems to support '98 operations, while the other one will be dedicated to MS '01. This item is open until we have succeeded in working out a schedule that covers remaining '98 development work along with test and training. Anticipate closure (by necessity) no later than about 07 Sep 98.

- **CDR-6**

MOS validation plan was completed last Spring; The test and training plan was established. We are just now in the process of integrating that plan with the ATLO/system test plans leading up to the MCO launch. This item is still open until we're sure our test and training activities have been worked for any potential conflicts with the '98 ATLO/system test team. Anticipate closure on or about 31 Aug 98.

- **CDR-7**

TMOD delivery schedule has been established.

- **Delta CDR-1**

Multi-day operational readiness test of MGS A/B in 1.9 hour orbit conducted on August 4,6,11,13 - nominal and with Contingency mode recovery. Successful!

- **Delta CDR-2**

Extensive analysis and testing has been performed. NASA HQs, JPL Director and MGS PSG briefed. PM's current position is for 30+ day period of mapping with undeployed HGA. Working new mission planning tools required to implement. Decision on duration on 2/3/99.

ACTION ITEM CLOSURE DETAILS

- **Delta CDR-3**

The Project has elected not to establish a special ANOMALY support team because of the paucity of workforce at JPL and LMA. The approach to ANOMALY support is to establish a list of backup personnel (which already exists) from spacecraft development and operations development who will be called upon to support special circumstances. Funding reserves for these activities has been established.

- **Delta CDR-4**

Each team considered this notion. Results vary from universal support by MP&S Team, Nav Team and RTO to dedicated subsystem specialists in the Spacecraft Team. Project organization and team management remain unchanged.

- **Delta CDR-5**

Updated analysis submitted the NASA Planetary Protection Officer, and deviated granted on 6/22/98 for the mission plan presented in the Delta-CDR.

Flight Operations Overview

MGS Aerobraking Phase 2

J. G. Beerer

Agenda

- Mission Plan
- Flight Profile Considerations
- Phase 1 Lessons Learned
- Operations Approach
- Contingency Plans
- Conclusions
- Flight Profile Charts (Back-up #1)
- Process Charts (Back-up #2)

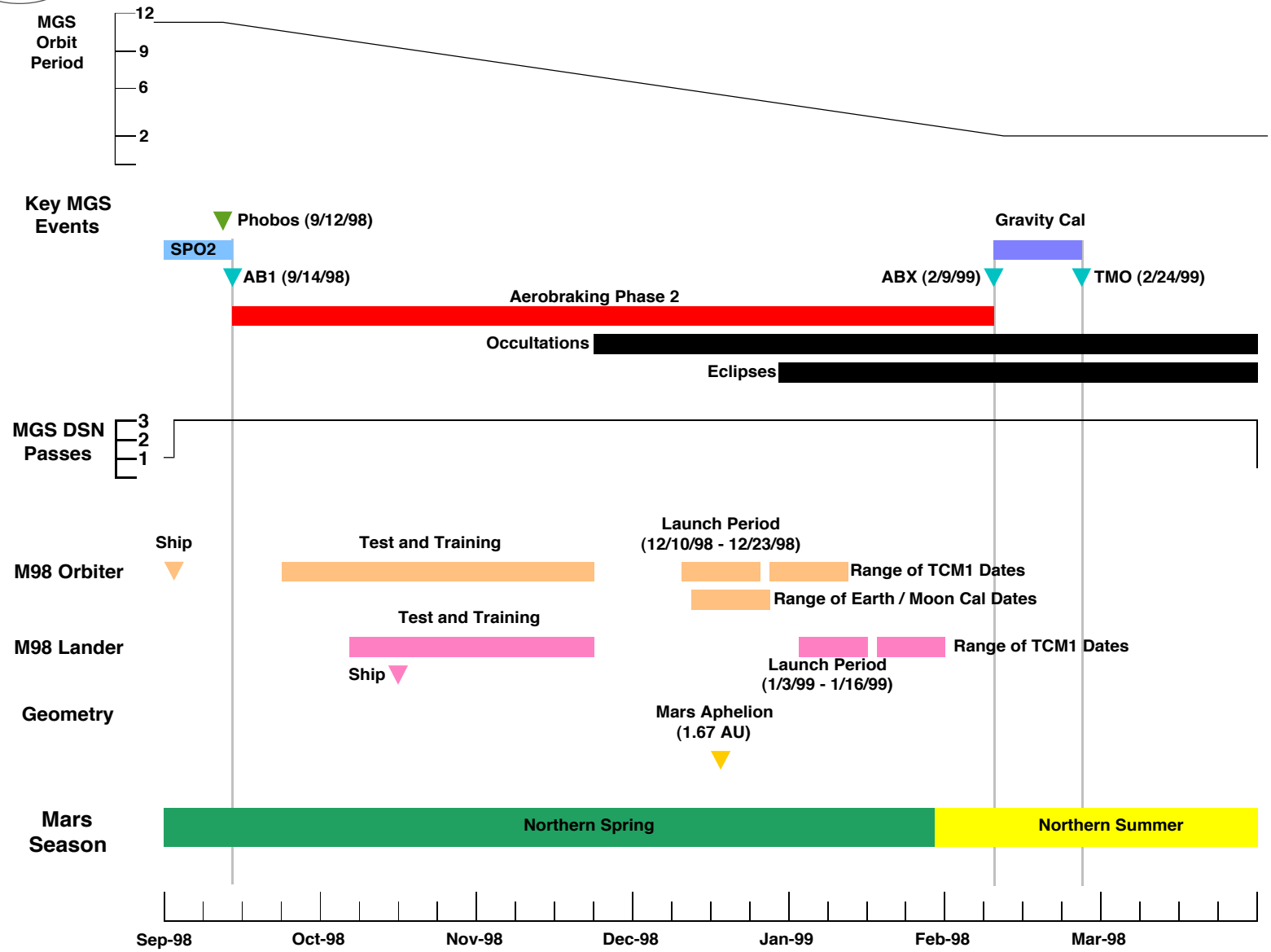
Mars Surveyor Operations

Mission Plan

- **Mission Plan Defined by Roncoli Presentation at Delta-CDR on 2/25/98**
  - **AB Phase 2: 9/11/98 through 2/3/99**
  - **Mapping Transition Options Identified**
- **Mission Plan Refined by Johnston Presentation to Ops Planning Meeting on 6/25/98**
  - **AB Phase 2: 9/14/98 through 2/9/99**
  - **Consistent with "Fast" Mapping Transition Option**
- **MCR Pending for "South Pole Gravity" Mapping Transition**
  - **9/1/98 MCR Distributed for Assessment**
  - **9/22/98 MCR to Change Board for Decision**
  - **10/15/98 Mission Plan Distributed for Review**
  - **11/10/98 Mission Plan MCR to Change Board**
- **HGA Deployment Decision Scheduled for 2/3/99**
  - **Period of "Magellan" Mapping Before Deployment**

Mars Surveyor Operations

MGS Mission Events



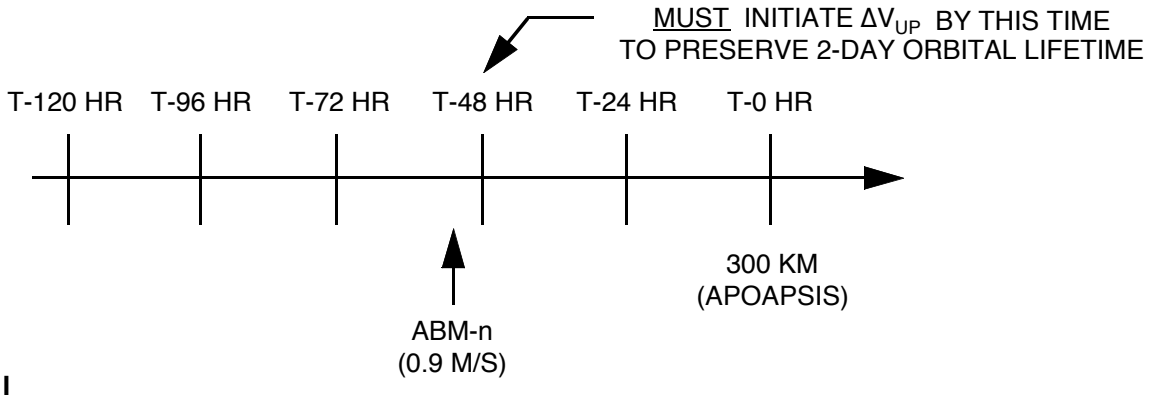
Flight Profile Considerations

- **Establishing the Mapping Orbit**
  - **Specific Targets at the Time of TMO Maneuver**
    - **Orbit Period = 118 min.**
    - **Node = 2 AM LMST**
    - **Inclination = 93.0 deg**
  - **Spacecraft Remaining ΔV Capability = 250 M/S**
    - **AB Phase 1 Provided ~220 M/S**
    - **AB Phase 2 Provides ~995 M/S**
- **Walk-in Strategy**
  - **Restart Date Is 9/14/98**
  - **Incorporate Inclination Correction at AB-1**
  - **Similar to Aerobraking Restart Last November**
    - **AB-1 (Orbit 554): $Q_{resultant}$ = 0.05 N/M2**
    - **AB-2 (Orbit 555): $Q_{resultant}$ = 0.10 N/M2**
    - **AB-3 (Orbit 557): $Q_{resultant}$ = 0.15 N/M2 (Corridor)**

Flight Profile Considerations (Cont'd)

- **Main Phase - Stepped Dynamic Pressure Corridor**
  - **Trajectory Design Limits Used:**
    - **1) 0.135 N/M^2 ≤ Q ≤ 0.235 N/M^2 (11.6 Hrs > Period ≥ 5 Hrs)**
    - **2) 0.085 N/M^2 ≤ Q ≤ 0.185 N/M^2 (5 Hrs > Period ≥ Walk-Out)**

- **Walk-Out - 2-Day Orbital Lifetime**
  - **Perform Periapsis Raise Maneuver (ΔV_{up}) at the Last Apoapsis Where the Time (Predicted) to Reach an Apoapsis Altitude of 300 Km ≥ 48 Hrs**



Mars Surveyor Operations

Phase 2 Operations Differences

- **Smaller Orbit Periods**
  - **11.5 to 1.9 Hr**
  - **Shorter Uplink Windows**
- **“Smoother” Atmosphere**
  - **Out of GLOBAL Dust Storm Season**
- **Drag Pass in New Atmosphere Regions**
  - **Southern Hemisphere**
  - **Polar Vortex**
  - **Cross Terminator**
- **Unproven South Pole MarsGRAM Model**
  - **Affects NAV Prediction Accuracies**
- **Limited Atmosphere Observing Methods**
  - **Accelerometer**
  - **MHSA**
  - **Kitt Peak Microwave**
  - **TES (Large Period Orbits Only)**

Phase 2 Operations Differences (Cont'd)

- **Gravity Causes Periapsis Altitude to Drift Downward**
  - **Mostly UP ABMs**
- **More Margin in Corridor Control Strategy**
  - **Dynamic Pressure Corridor is Lower in Phase 2**
  - **Enables a "Mechanical" ABM Decision Process**
- **Limited Science Data Collection**
  - **Short Science Record Around Periapsis**
  - **5-min PB On Outbound Leg**
  - **No "W" Sequences**

Mars Surveyor Operations

Phase 1 Lessons Learned

- Held Lessons Learned Workshop on 6/9/98
- Objective Was To Identify Process Improvements
- Each Team Presented Its Assessment & Recommendations
- 19 Action Items Were Assigned
- All Items Are Closed But Three
- Items Addressed:
  - Increasing Number of Orbits Nav Can Predict Accurately
  - Shortening the APG Meeting
  - Planning Product Delivery Schedules
  - Facilitating Sequence Uplink Traffic
  - Quicker Response to Ground System Anomalies
  - Contingency Plans
- Aerobraking Processes Were Reviewed and Updated
  - See Backup Charts #2

Mars Surveyor Operations

Lessons Learned Action Items

No.	Item	Assignee	Due Date	Status
1	Determine if 225 s time of periapsis prediction requirement on Nav can be relaxed.	Spath	7/15/98	Closed by Spath e-mail, 7/16/98
2	Compile list of file access and connectivity problems encountered in Phase 1 AB.	Sidney	7/01/98	Closed by Sidney e-mail, 6/25/98
3	For items in Sidney list from AI #2 that are ASP-related, describe the appropriate remedial action.	Brooks	8/01/98	Closed by Brooks e-mail, 8/21/98
4	For items in Sidney list from AI #2 that are TMOD-related, describe the appropriate remedial action.	Recce	8/01/98	Closed. Sidney list has only ASP-related items
5	Determine if CM to CF offset should be applied to triaxial ellipsoid model for computing s/c altitude.	Esposito	7/17/98	Closed by Esposito e-mail, 7/20/98
6	Assess means of generating OPTG/SPK files if post periapsis tracking data is unavailable.	Esposito/Spath	7/30/98	Closed with Spath e-mail 7/16/98, and Esposito e-mail 7/28/98
7	Test new software and procedures from AI #6.	Esposito	8/24/98	S/W test complete, procedures in work
8	Write MCR to increase stored sequence buffer to accommodate at least 18 orbits.	Sidney	6/23/98	Closed by MCR 261, 6/23/98
9	Write training procedures for SCT to use ASP installed at LMA.	Brooks	8/03/98	Closed by Brooks e-mail, 8/18/98
10	Define Phase 2 dynamic pressure corridor limits for flight profile design.	Johnston/Spath	6/12/98	Closed by Johnston e-mail, 6/16/98
11	Define operational corridor control strategy	Johnston/Spath	7/24/98	Closed by Spath e-mail 7/20/98 & Johnston presentation at 7/23/98 Ops Plan. Mtg.
12	Write procedures for responding to Communication outages.	Bucher/Recce	9/15/98	
13	Review and update OIAs for changes for Phase 2.	Brower/TCs	8/01/98	Closed by Brower e-mail, 8/21/98
14	Provide Recce DKF/p-file delivery schedule for Phase 2.	Lee	7/30/98	Closed by Lee e-mail, 8/21/98
15	Define period when ECC activation requirement will be less than 72 hours and update the PR/TSA.	Whetsel/Brower	7/01/98	Closed with AI#16
16	Define Level 1 & 2 support periods in Phase 2	Beerer	7/15/98	Closed with Beerer e-mail to McKinney, 7/16/98
17	Provide trending plots of dynamic pressure for APG mtgs.	Short	8/01/98	Closed by Spath e-mail, 6/23/98
18	Publish Mars physical constants memo. Include project recommended geoid model.	Esposito	9/09/98	
19	Identify "standardized" inputs for APG meetings.	Zurek/Spath/Esposito	8/01/98	Closed by e-mails, 7/1/98, 8/21/98

Operations Approach - Drag Sequences

- **Modify Sequence Build Schedule as Orbit Shrinks**
  - **Stay With One Build Per Day As Long as Possible**
    - **Maintains Prime Shift Work For Most of Team**
    - **Depends on Nav's Ability to Meet 225 s Tp Prediction**
    - **Occasionally Need Additional (Offshift) Build If Timing Exceeded**
  - **Switch to Two Builds Per Day When Timing Regularly Exceeds 225 s**
  - **Walkout Will Require 2-4 Builds Per Day**
- **Will Have 12 hr Worth of Backup Orbits on Board**
  - **Accounts for Station Outage**
  - **After Backup Orbits Expire, Sequence Commands C-Mode**
    - **Drag Pass Won't Be Entered on Wheels**
- **Command Conferences Chaired By LMA Spacecraft Uplink Manager (SCUM)**

Drag Sequence Build Strategy

Hours Req.

nav	6
sct/seq	1
uplink	1
pre-peri	1

Uplinks per Day

	1	2	3	4	Date
11	2 / p1	1 / p1			20-Sep-98
10	2 / p1	1 / p1			30-Sep-98
9	3 / p1	2 / p1			10-Oct-98
8	4 / p2	3 / p2	2 / p2		21-Oct-98
7	5 / p2	3 / p2	3 / p2		3-Nov-98
6	5 / p2	3 / p2	3 / p2	2 / p2	17-Nov-98
5	6 / p2	4 / p2	3 / p2	3 / p2	2-Dec-98
4	8 / p3	5 / p3	4 / p3	4 / p3	24-Dec-98
3	10 / p3	6 / p3	5 / p3	4 / p3	15-Jan-99
2	16 / p5	10 / p5	8 / p5	7 / p5	5-Feb-99

x/py: **x = no. of prediction orbits with Tp error less than 225 s**

py = predicted orbit no. y is first orbit in the sequence

Mars Surveyor Operations

Operations Approach - Maintain Glide Slope

- **Weekly Reset Meeting on Wednesdays**
  - **Planned Maneuvers Noted**
  - **Assess Orbit Period Reduction Progress**
  - **Adjust Corridor Upper Limit If Required**
  - **ABM Magnitude Menu Identified**
  - **M'98 Coordination**
- **One Orbit Per Day Designated as ABM Opportunity**
  - **Will Be On Prime Shift**
  - **Selected Not to Perturb On-Board Sequence Timing**
  - **Will Be Identified at Weekly Reset**
- **Daily APG Meeting for Maneuver Decision**
  - **Use N-Orbit Running Mean on Dynamic Pressure**
  - **FOM Approves ABM Build**
  - **SCUM Chairs Command Conference**

Operations Approach - Immediate Action ABM

- **Immediate Action Procedure**
  - **SAM Health Parameters & Dynamic Pressure**
    - **Yellow Limit Exceeded - Raise Altitude, But Stay In Atmosphere**
    - **Red Limit Exceeded- Pop-up, Out of Atmosphere**
  - **ACE and SYS Assess Parameters After EACH Periapsis**
  - **FOM Notified if Limit Exceeded**
  - **FOM Decides if Maneuver Required & Approves ABM Build**
  - **SCUM Chairs Command Conference**
  - **Change to Procedure for Small Orbits**
    - **Cannot React On Same Orbit After Seeing An Anomaly**
    - **Will Often Require Extra Drag Sequence Build to Correct Periapsis Timing**

Mars Surveyor Operations

FOM Shift Schedule

- **Walkin & Mainphase**
  - **FOM On Site**
    - **During Prime Shift 8:30 am - 5:30 pm PT, Monday - Friday**
    - **Normally Will Be Beerer**
  - **FOM On Call**
    - **During Off Shift Periods**
    - **Beerer, Brower, Neuman and Whetsel Rotation**
    - **12 Hour Shifts**
    - **3.5 Shifts Per Week**
    - **FOM Shift Schedule on AFS**
- **Walkout**
  - **FOM On Site**
    - **Around-the-Clock (24/7) from 2/1/99 to 2/9/99**
    - **Beerer, Brower, Neuman and Whetsel Rotation**

AAG Support

- **Atmosphere Advisory Group**
  - **Richard Zurek, Lead**
  - **Accelerometer Team (Keating, Tolson, et al.)**
  - **MHSA (T. Martin)**
  - **Microwave (T. Clancy)**
  - **TES (J. Pearl)**
- **AAG Will Meet Daily Initially**
  - **Expect to Reduce to Tues and Fri Meetings After 2 Weeks**
- **AAG Will Provide Weekly Input to Reset Meeting**
  - **Atmosphere Assessment & Forecast**
- **Accel Will Provide Daily Inputs to APG**
  - **Predicts for Future Periapsis Dynamic Pressure**
- **Accel Will Provide Daily (Possibly by Orbit) Inputs to Nav**
  - **Periapsis Density and Scale Height**

Mars Surveyor Operations

Meeting Schedule

- **Weekly Reset Meetings**
  - **Wednesdays at 8:00 am PDT**
  - **Coordination with M'98**
- **Drag Sequence Command Conferences**
  - **Per Weekly Reset ASTI Schedule**
  - **Normally 9 am or 4 pm PDT (10 am or 5 pm MDT)**
- **ABM Sequence Command Conferences**
  - **Per Weekly Reset ASTI Schedule**
  - **Normally 9 am or 4 pm PDT (10 am or 5 pm MDT)**
  - **Scheduled to Not Conflict with Drag Sequence Cmd Conf's.**
- **SCT Meeting @ 9:30 am PDT (10:30 am MDT) Daily**
  - **Coordination with M'98**
- **AAG Meeting @ 11:30 am PDT (12:30 pm MDT) Daily**
- **APG Meeting @ 1:00 pm PDT (2:00 pm MDT) Daily**

Mars Surveyor Operations

Operations Contingency Plans

- **Pop-up Maneuver Required**
  - **Propellant allocated for one pop-up and return**
  - **Return to atmosphere repeating walkin strategy**
- **Pop-up Maneuver Threatens Ability to Reach 2:00 am Orbit**
  - **Increase dynamic pressure corridor limits**
  - **If can't meet 2:00 am, press on to best LMST (1:00 am?)**
  - **Form Tiger Team to work with PSG to find best final orbit**
  - **Coordinate with M'98 to avoid event conflicts**
- **Scheduled DSN Pass Becomes Unavailable**
  - **"Backup" orbits in sequence will handle some cases**
  - **If available, schedule BWG or downlink-only station**
  - **If critical ABM uplink required, declare s/c emergency and acquire station**
- **Post Periapsis Tracking Data Lost**
  - **Nav will use accelerometer-measured drag pass delta-V to generate OPTG/SPK**

Conclusions

- **Baseline Flight Profile is Complete**
  - **Except For Mapping Transition Plan (Pending MCR)**
- **Contingency Plans are Complete**
- **Flight Team Is Ready to Resume Aerobraking**
- **Aerobraking Scheduled to Resume on 9/14/98**

Mars Surveyor Operations

MSOP AEROBRAKING PROCESSES

Aerobraking Operations Decision Process — Johnston

	Lead (Assistant)
1. Spacecraft Health Monitor Process	Spath
2. NAV and Sequence Update Process	Sidney
3. Weekly Reset Process	Spath
4. Maneuver Design Process	Spath (Esposito)
5. ABM Decision and Implementation Process	Johnston (Sidney)
6. Atmospheric Modeling Process	Esposito (Neuman)
7. Mars Atmospheric Advisory Process	Whetsel (Zurek)

AEROBRAKING OPERATIONS DECISION PROCESS

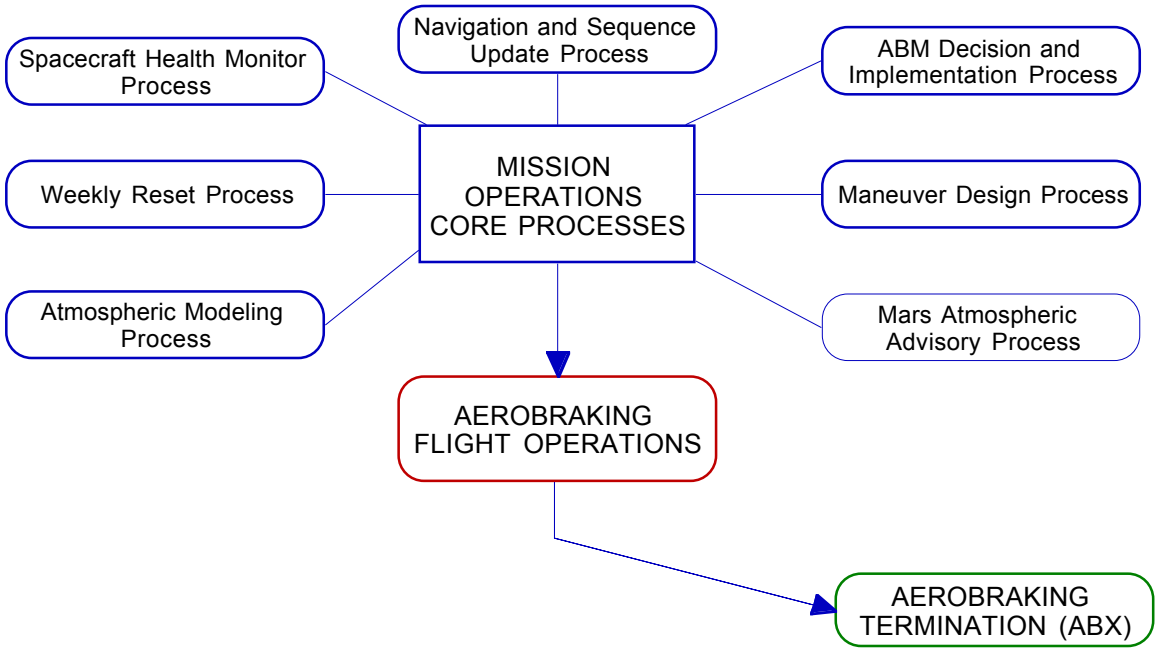
- **PROVIDES A FUNDAMENTAL FRAMEWORK TO FACILITATE FLIGHT OPERATIONS PLANNING AND DECISION MAKING DURING AEROBRAKING**

  => AEROBRAKING OPERATIONS ARCHITECTURE

  - **PROVIDES A SYSTEMS LEVEL VIEW OF AEROBRAKING OPERATIONS**
  - **BASED ON THE USAGE OF THE MISSION OPERATIONS SYSTEM (MOS) CORE PROCESSES**
  - **ILLUSTRATES (AT THE PROCESS LEVEL) THE DATA PATHS AND FLOW NECESSARY TO SUPPORT AEROBRAKING OPERATIONS DECISION MAKING - SHOWS THE MOS PROCESS INTERACTION AS PARALLEL AND SERIAL ACTIVITIES**
  - **IDENTIFIES KEY DECISION JUNCTURES THAT LEAD EITHER TO THE NEXT AEROBRAKING SUB-PHASE OR A PATH THAT MAY FORCE AN AEROBRAKING DELAY**

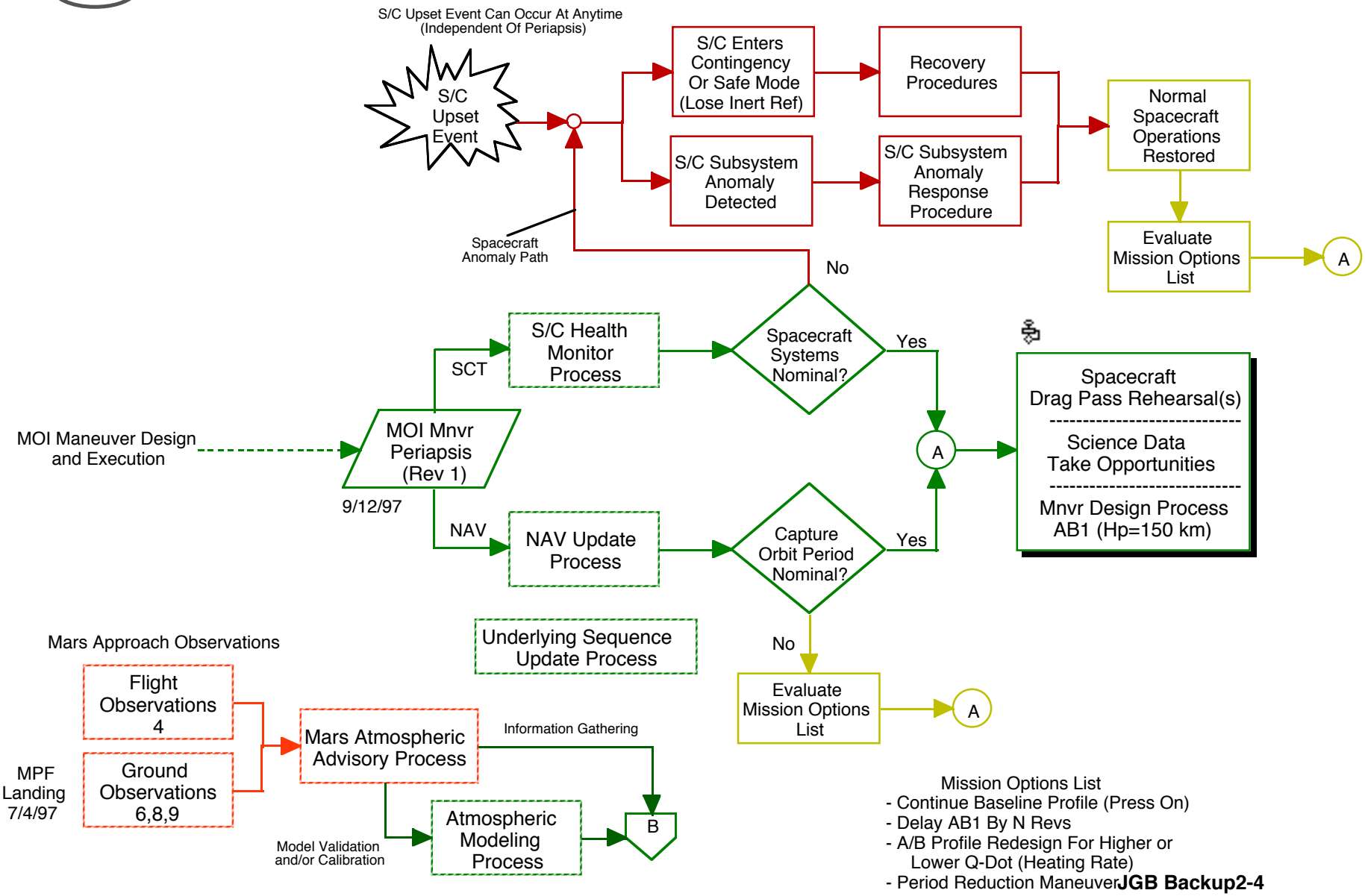
AEROBRAKING OPERATIONS DECISION PROCESS

OVERVIEW



AODP PHASE 1 - FINAL AEROBRAKING PREPARATIONS

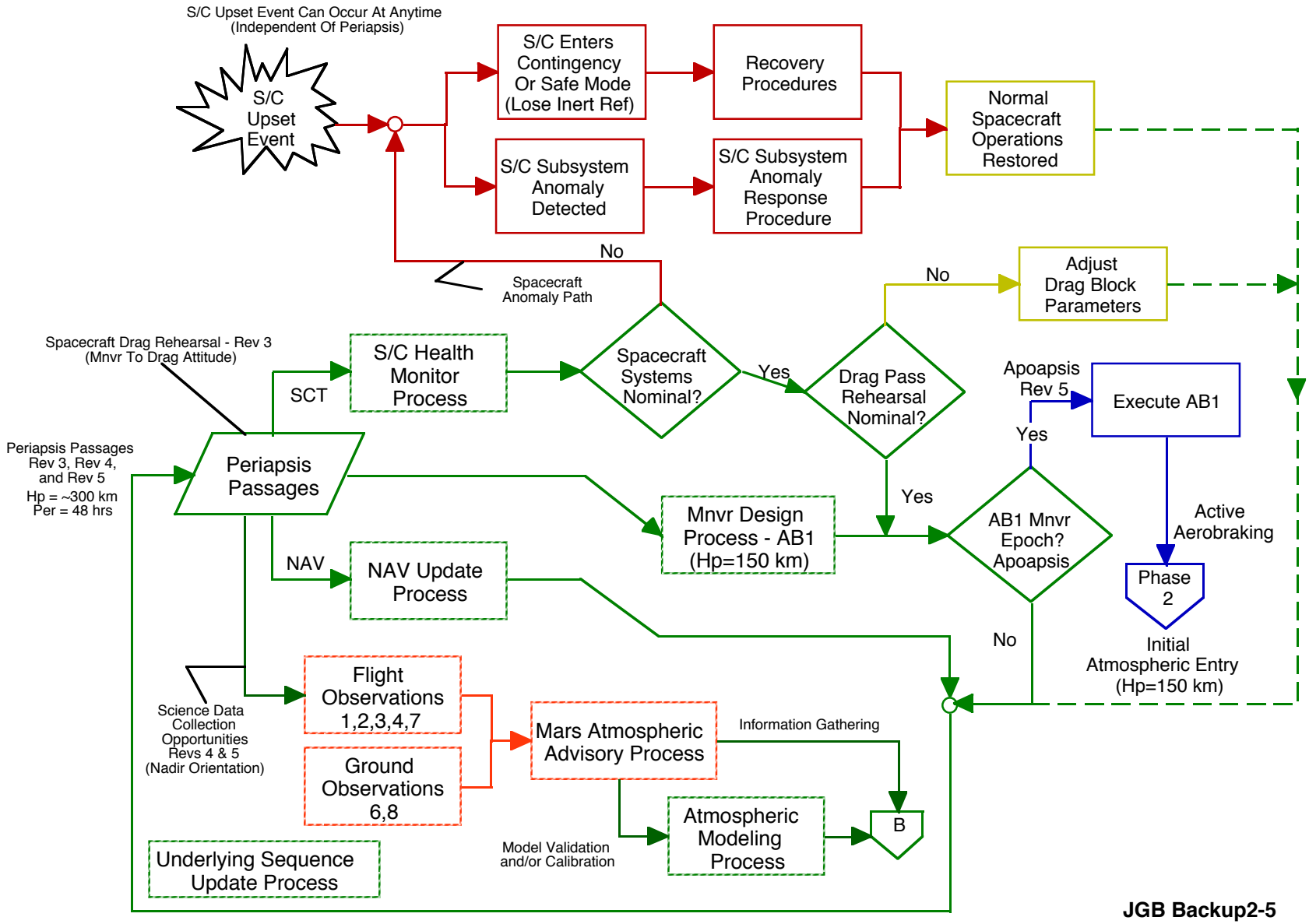
MARS APPROACH OBSERVATIONS / CAPTURE ORBIT ASSESSMENTS



JGB Backup2-4

AODP PHASE 1 - FINAL PRE-AEROBRAKING PREPARATIONS

SPACECRAFT DRAG REHEARSALS / AB1 MNVR DESIGN



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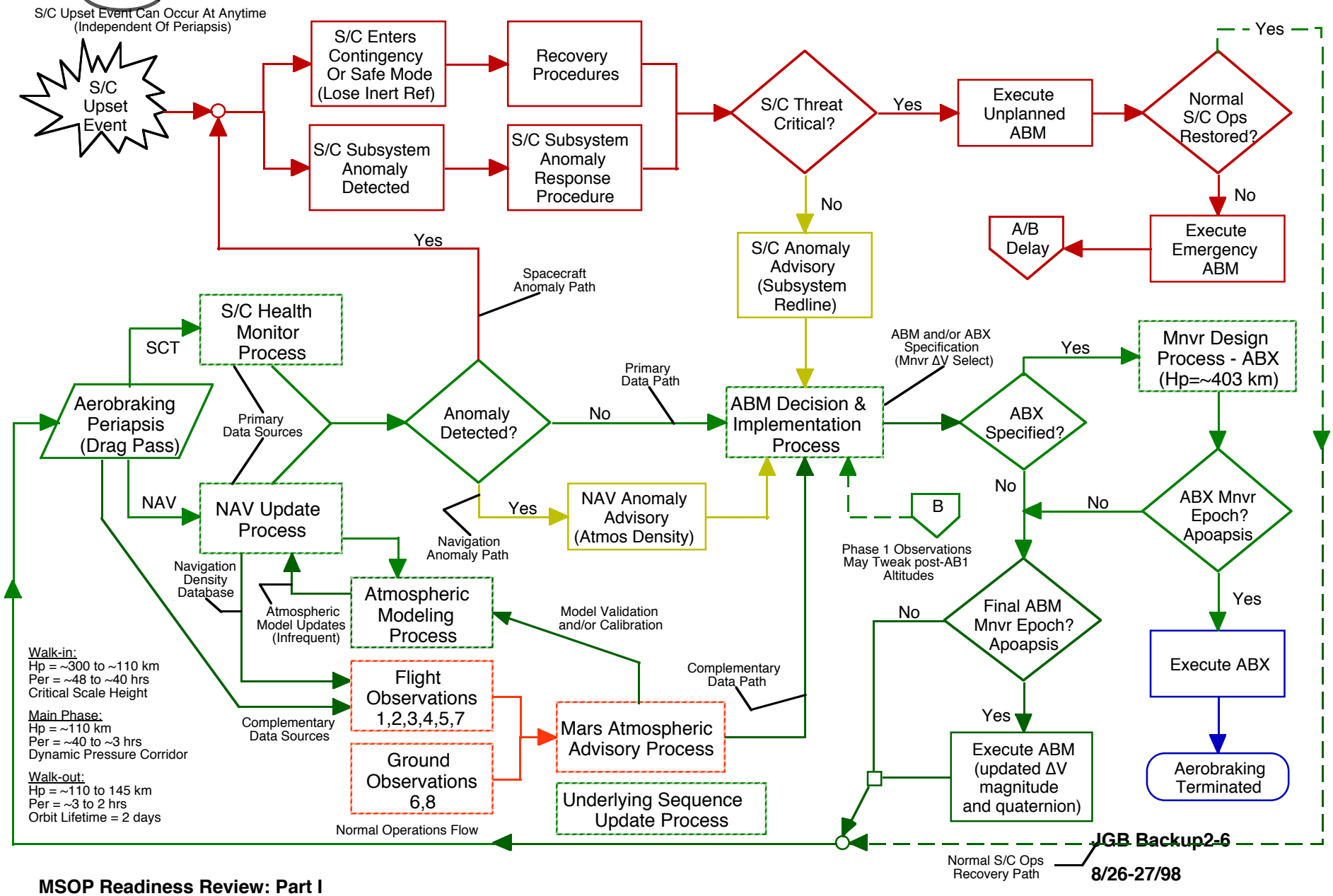
8/26-27/98

AODP PHASE 2 - ACTIVE AEROBRAKING

WALK-IN, MAIN PHASE, WALK-OUT



MISSION OPERATIONS CORE PROCESSES (1 OF 2)

- **SPACECRAFT HEALTH MONITOR PROCESS**
  - **TO MONITOR SPACECRAFT HEALTH AND PREDICT SPACECRAFT PERFORMANCE**
- **NAVIGATION AND SEQUENCE UPDATE PROCESS**
  - **TO GENERATED TRIGGER COMMANDS FOR SPACECRAFT DRAG PASS SCRIPTS AND TO GENERATE SPACECRAFT EPHEMERIDES**
- **WEEKLY RESET UPDATE PROCESS**
  - **TO UPDATE SPACECRAFT SCRIPT PARAMETERS DUE TO ORBIT PERIOD CHANGES AND TO COMMAND SCIENCE ACTIVITIES**
- **MANEUVER DESIGN PROCESS**
  - **TO DESIGN AND IMPLEMENT THE CRUISE TCM'S (TRAJECTORY CORRECTION MANEUVERS) AS WELL AS OTHER SELECT PROPULSIVE MANEUVERS (I.E. MOI, AB1, ABX, TMO, ETC.)**

MISSION OPERATIONS CORE PROCESSES (2 OF 2)

- **ABM (AEROBRAKING TRIM MANEUVER) DECISION AND IMPLEMENTATION PROCESS**
  - **TO SELECT AND IMPLEMENT THE NEXT AEROBRAKING WALK-IN MANEUVER POST-AB1 (AB2/AB3/AB4/AB5/AB6/ABi) AND TO SELECT AND IMPLEMENT THE NEXT AEROBRAKING TRIM MANEUVER (ABM1, ABM2, ABM3, ... ABMj) FOR TRAJECTORY CONTROL (I.E. CORRIDOR CONTROL MAINTENANCE)**

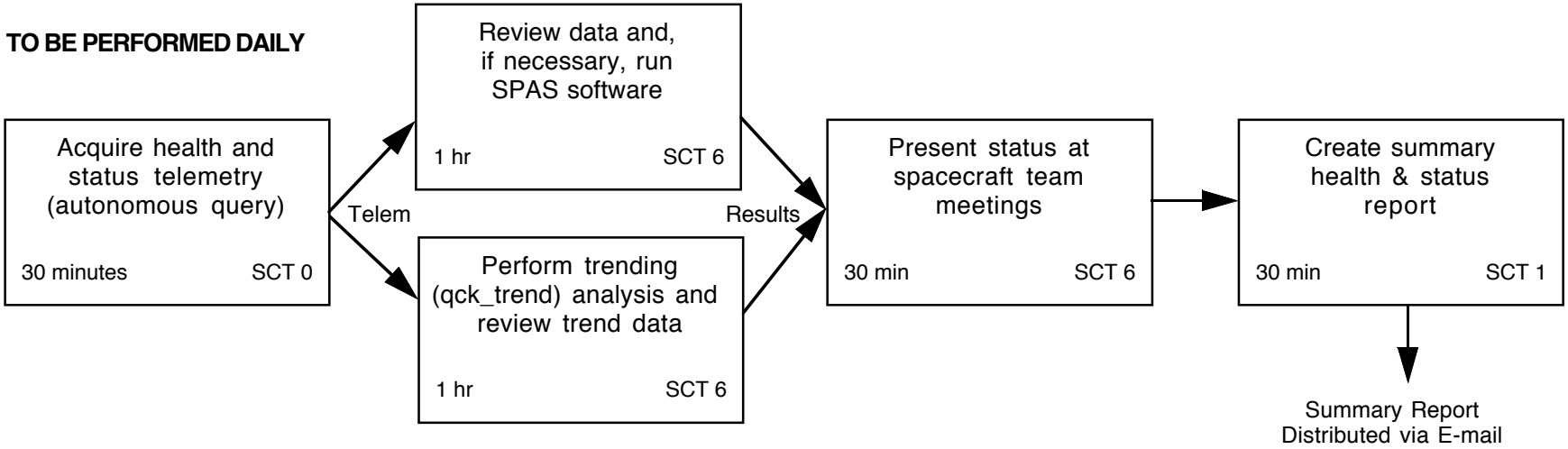
- **ATMOSPHERIC MODELING PROCESS**
  - **TO UPDATE THE MARTIAN ATMOSPHERIC MODEL TO REFLECT CHANGING ATMOSPHERIC CONDITIONS AND TO BETTER UNDERSTAND ATMOSPHERIC BEHAVIOR**
  - **TO VALIDATE AND/OR CALIBRATE MARS-GRAM 3.5 FOR USAGE BY THE FLIGHT TEAM -- BASED ON THE RECENT MARTIAN ATMOSPHERIC OBSERVATIONS (FLIGHT AND GROUND)**

- **MARS ATMOSPHERIC ADVISORY PROCESS (NEW)**
  - **TO PROVIDE A SINGLE INPUT INTO THE ABM DECISION AND IMPLEMENTATION PROCESS THAT SYNTHESIZES THE RECENT MARTIAN ATMOSPHERIC OBSERVATIONS (FLIGHT AND GROUND) AND TO THE EXTENT POSSIBLE A PREDICTIVE CHARACTERIZATION OF THE OBSERVED ATMOSPHERE -- COUPLED TO THE USAGE OF THE GCM LIBRARY**

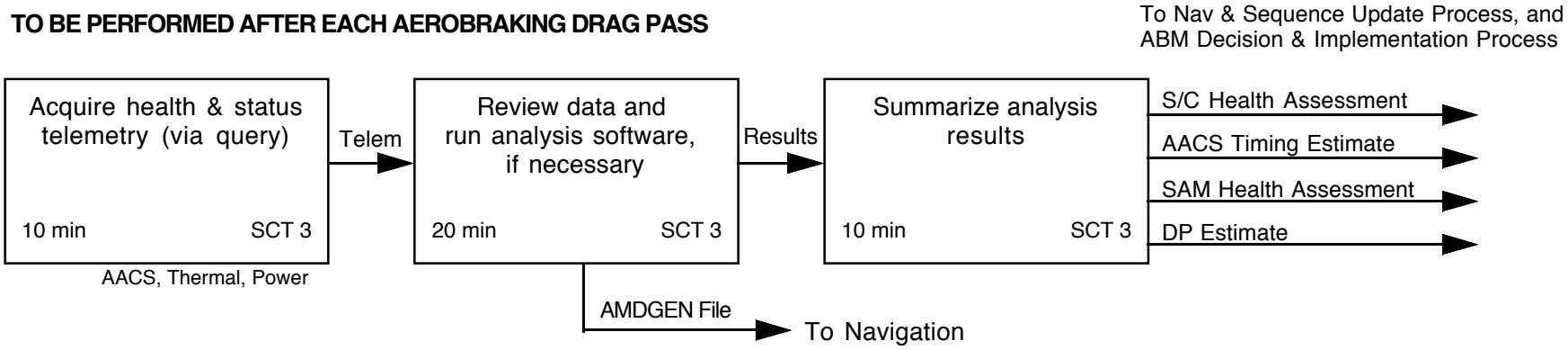
Mars Surveyor Operations

Spacecraft Health Monitor Process

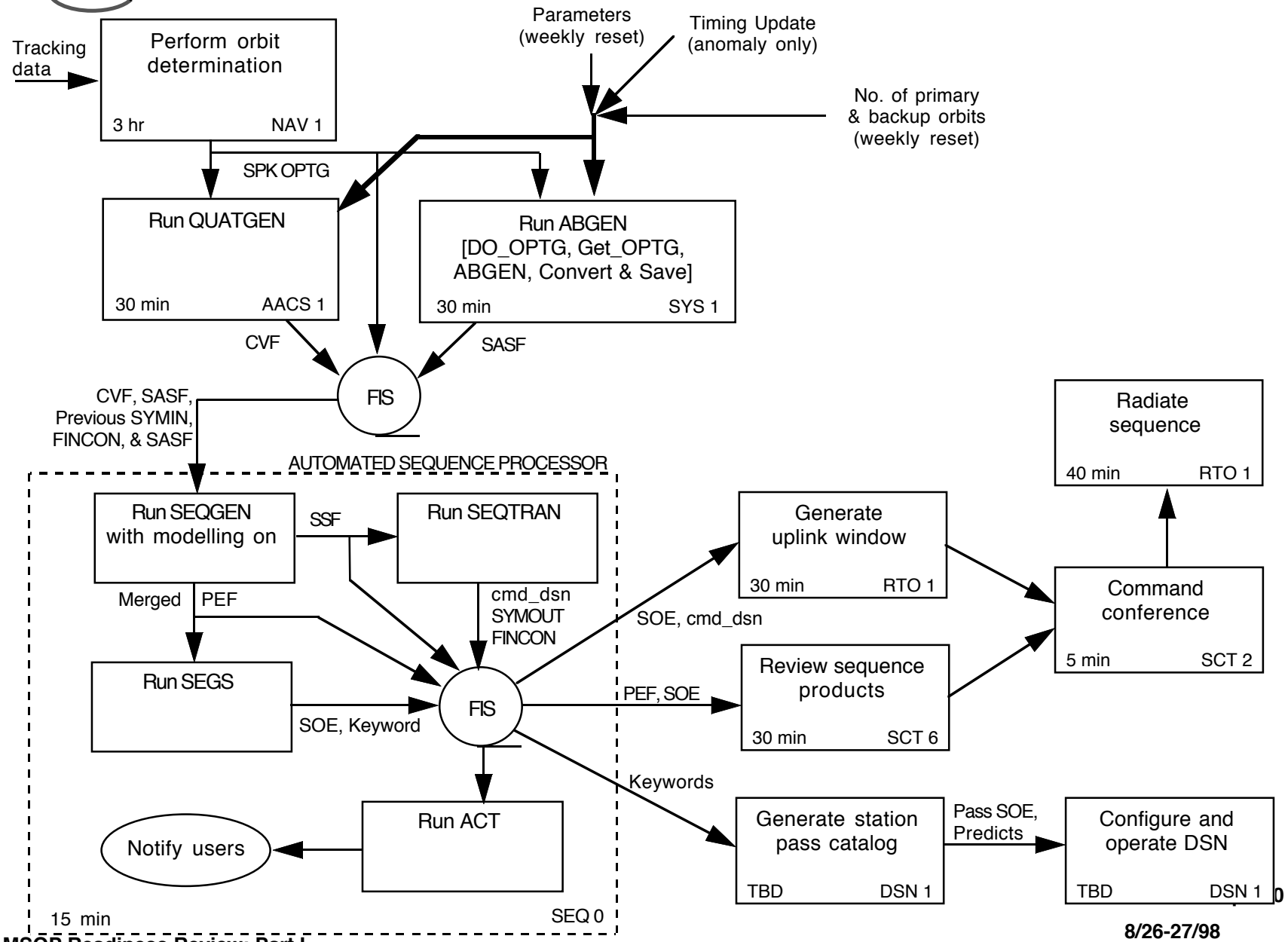
TO BE PERFORMED DAILY



TO BE PERFORMED AFTER EACH AEROBRAKING DRAG PASS

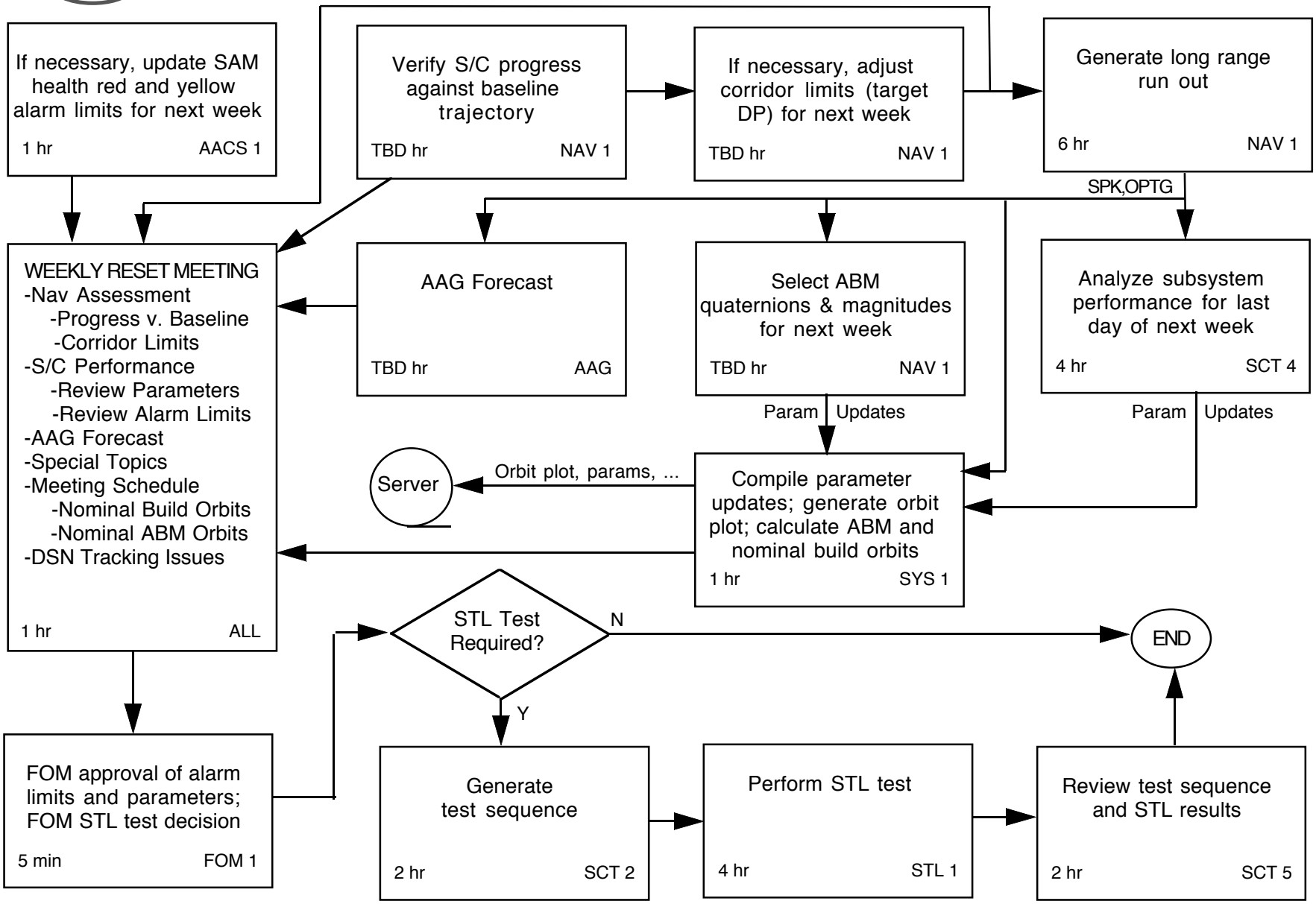


Nav & Sequence Update Process



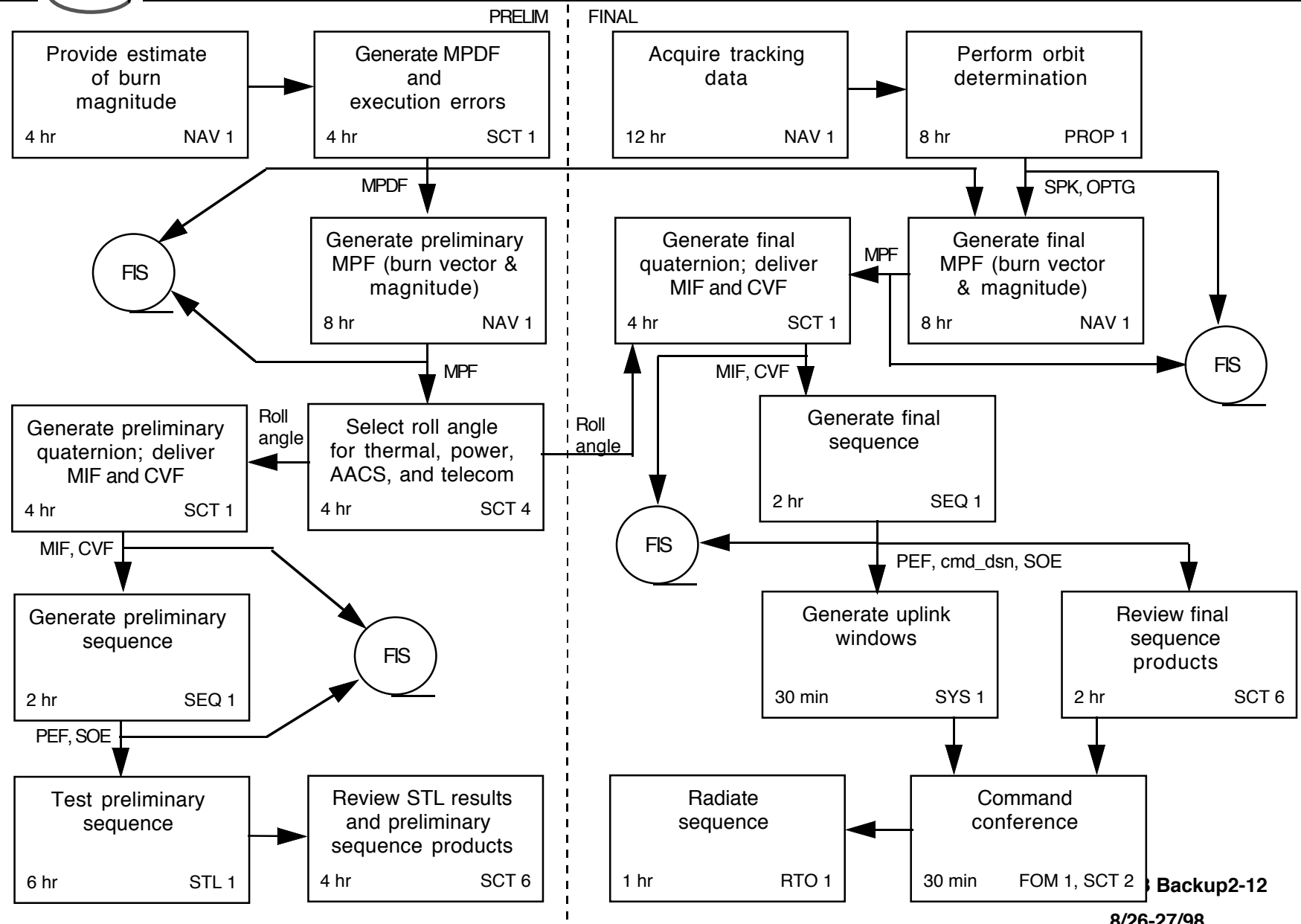
Mars Surveyor Operations

Weekly Reset Process

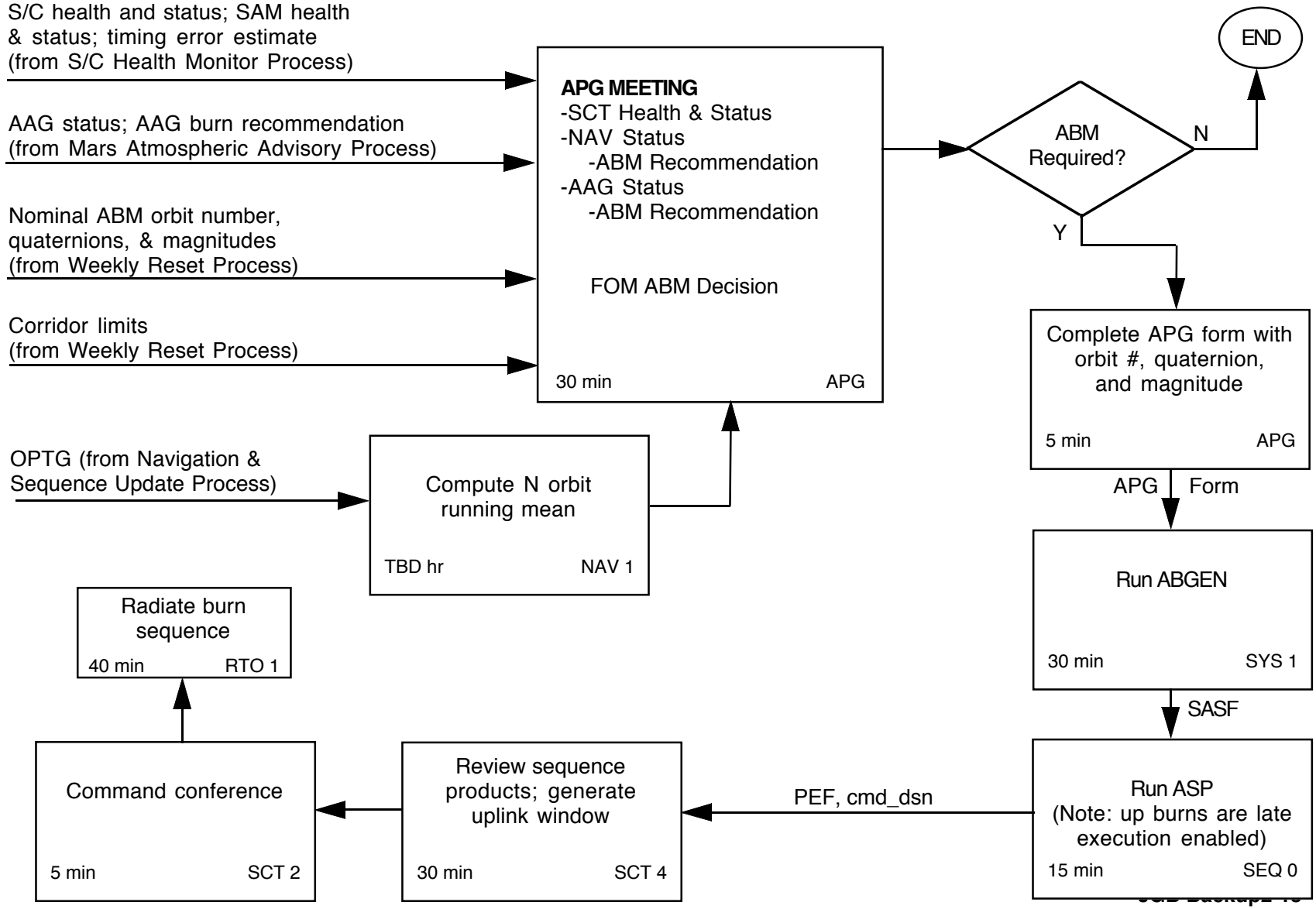


Mars Surveyor Operations

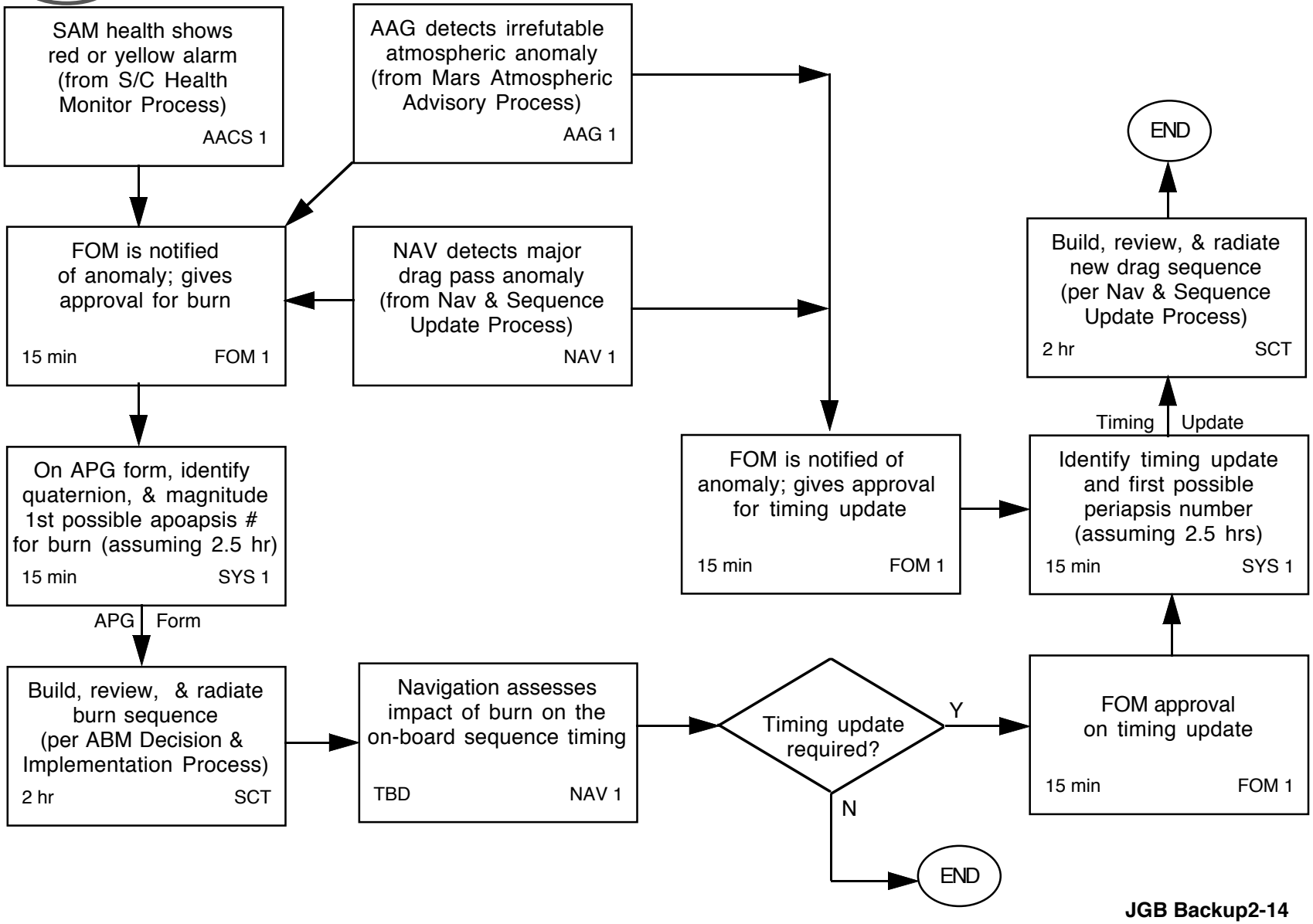
Maneuver Design Process



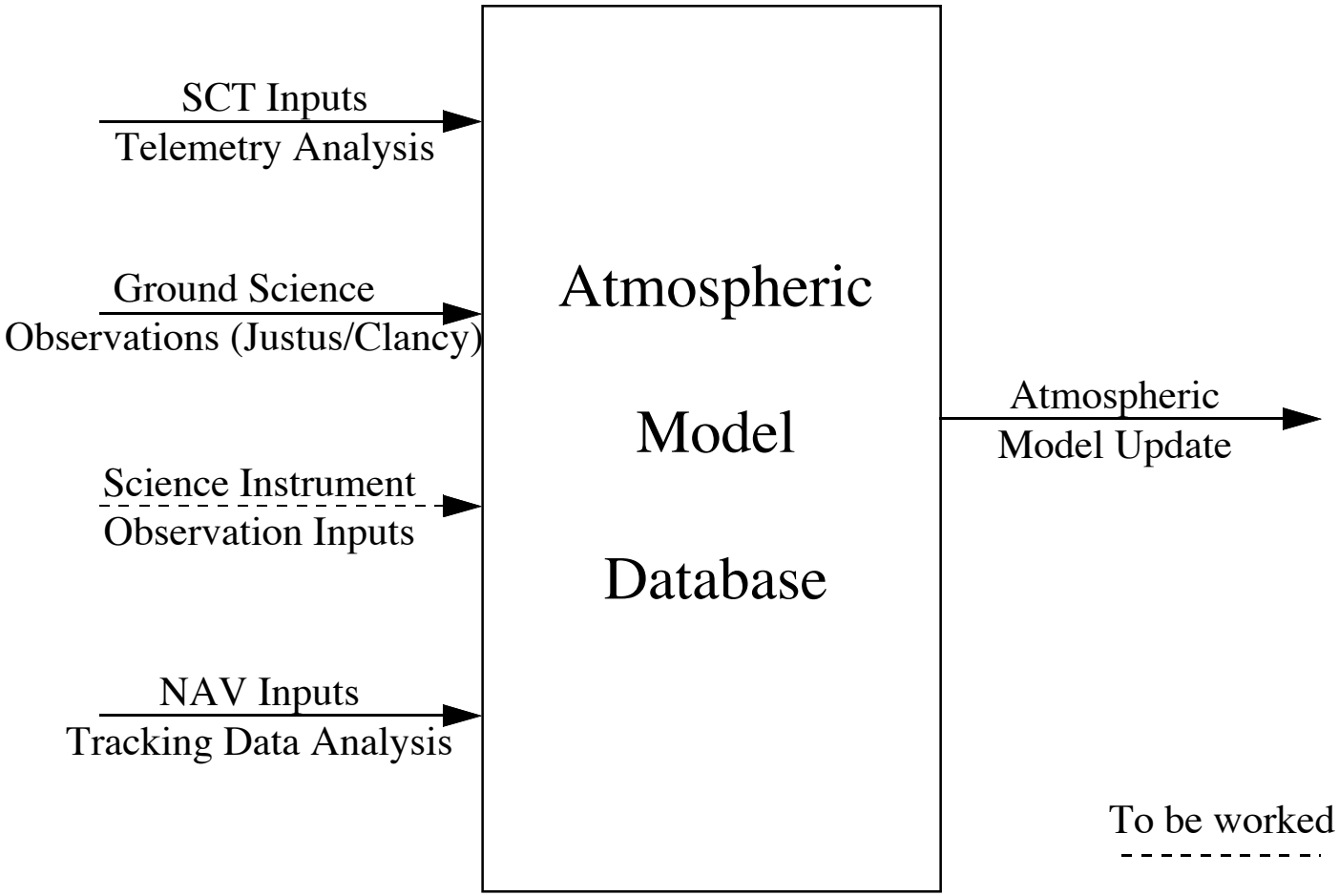
ABM Decision & Implementation Process



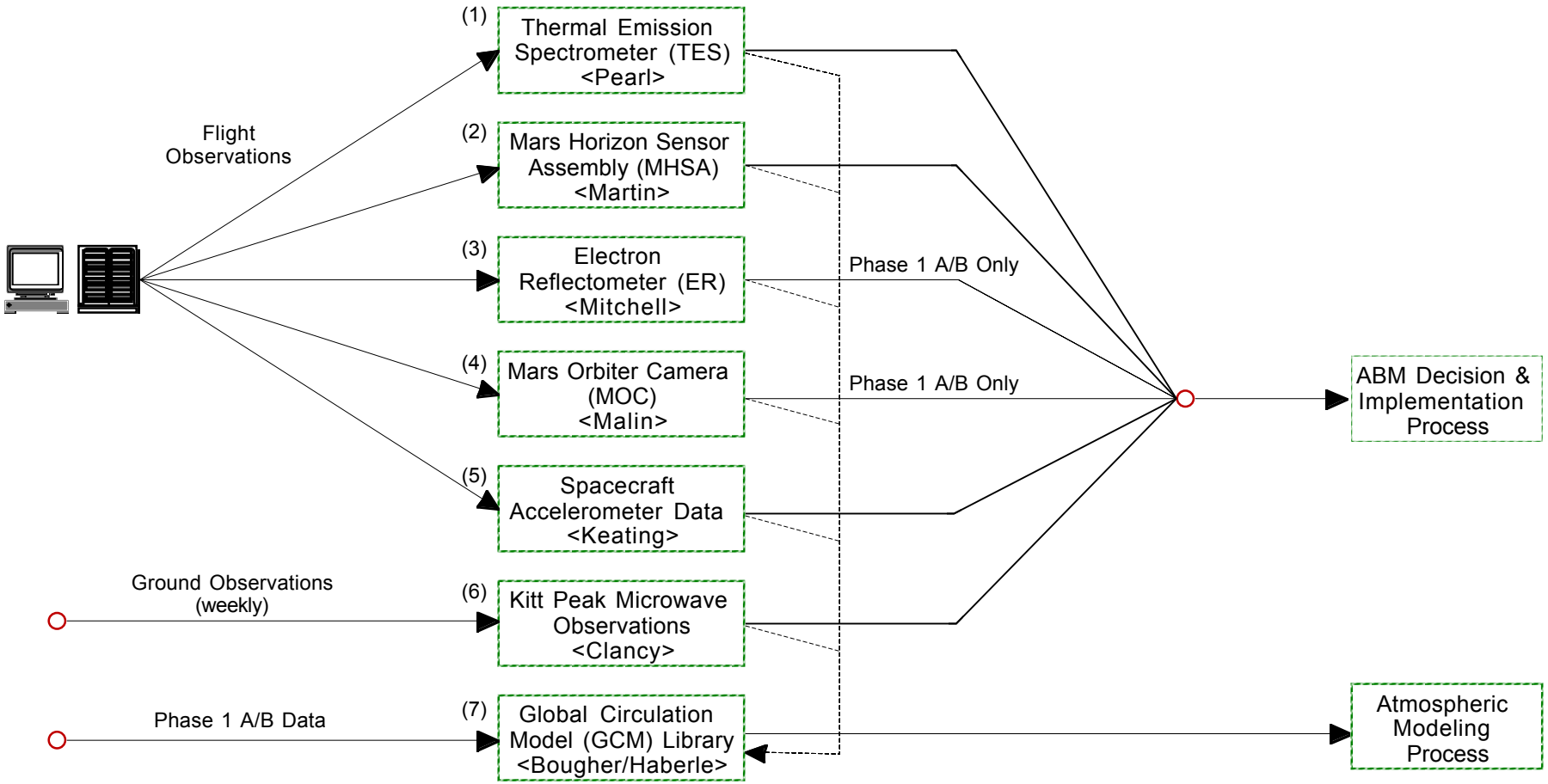
ABM Decision & Implementation Process
Immediate Action



Atmospheric Modeling Process



Mars Atmospheric Advisory Process



MCO/MPL FLIGHT OPERATIONS OVERVIEW

S. W. Thurman

P. C. Knocke

S. Lopez

C. W. Whetsel

26 August 1998

AGENDA

- **Key New Operations Requirements**
  - **Mars Climate Orbiter (MCO)**
  - **Mars Polar Lander (MPL)**
- **Mission Description**
  - **Overview**
  - **Launch/Initial Acquisition**
  - **Interplanetary Cruise**
- **Flight Operations Preparations**
  - **Flight Team Composition**
  - **Plans and Procedures**
  - **Test and Training**

NEW OPERATIONS REQUIREMENTS

- **Uplink Process**
  - **High level commanding via onboard sequence blocks**
  - **GDS interface to spacecraft file system**
  - **MPL performance envelope prediction for surface mission**
  - **MVACS sequence development to fit MPL envelope**
- **Downlink Process**
  - **Flight team management of Downlink Priority Table (DPT)**
  - **Processing and distribution of packetized telemetry**

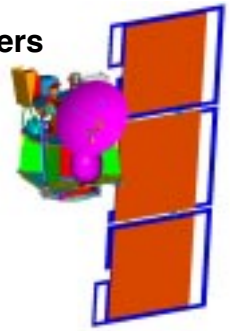
DOCUMENTATION

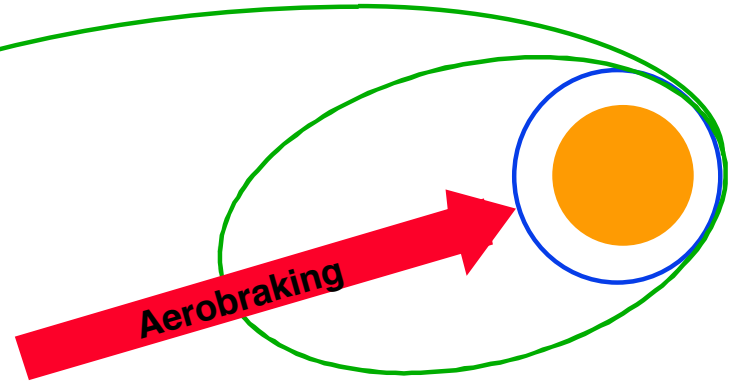
- MS ’98 / MSOP Memorandum of Understanding (Mar. 1997)
- MS ‘98 Project Policies and Requirements (Aug. 1997)
  - Final pre-launch archive version planned for Nov. 1998
- MS ‘98 Mission Plan and Databook (Aug. 1997)
  - Final pre-launch version planned for Nov. 1998
- Flight Rules and Constraints (Aug. 1998)
- Command/Telemetry Dictionaries
  - MCO launch baseline: Sep. 9 (tlm) and Oct. 15 (cmd)
  - MPL launch baseline: Nov. 4 (tlm) and Nov. 16 (cmd)
- Block Dictionaries
  - MCO launch baseline: Sep. 30
  - MPL launch baseline: Oct. 27

MISSION OVERVIEW

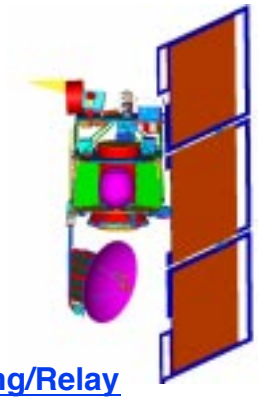
MCO MISSION OVERVIEW

Cruise
- 4 Trajectory Correction Maneuvers
- 10 Month Cruise

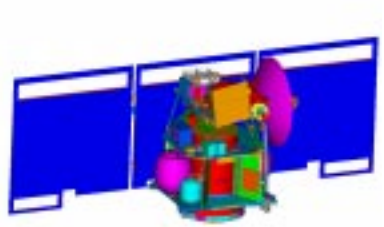




Launch
- Delta 7425
- Launch 12/10-25/98
- 2/day launch opportunities
- 629 kg Launch Mass



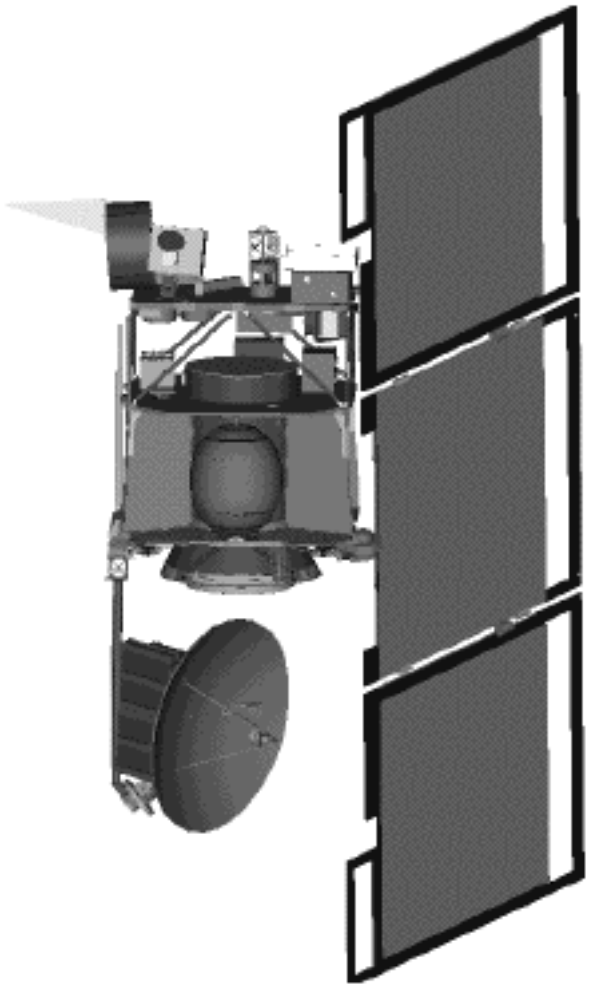
Mapping/Relay
- 12/3/99 - 3/1/00: Mars Polar Lander Support Phase
- 3/00 - 1/02 Mapping Phase
  - PMIRR & MARCI Science
- Relay for future Landers



Mars Orbit Insertion & Aerobraking
- Arrival 9/23/99 - 10/4/99
- MOI is the only use of the main [biprop] engine. The 16 minute burn depletes oxidizer and captures vehicle into 16-18 hour orbit.
- Subsequent burn using hydrazine thrusters reduce orbit period further.
- Aerobraking is designed to be completed prior to Mars Polar Lander arrival [12/3/99].

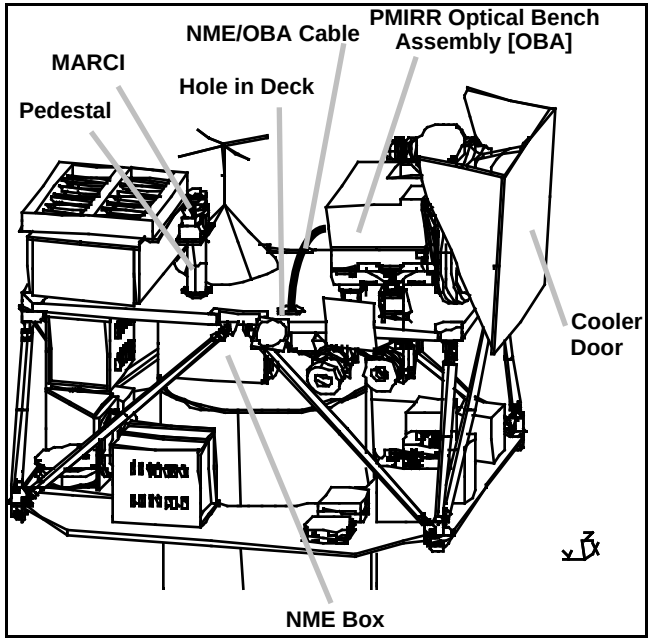
MCO FLIGHT SYSTEM

- **AACS:**
  - 3 axis stabilized
  - Reaction wheels desaturated via RCS thrusters
  - IMUs turned off during significant portions of Cruise, Mapping [all-stellar mode] except during maneuvers
    - » IMU lifetime concerns.
  - Star camera + IMU, backed up by analog sun sensors
  - 4 5-lbf TCM thrusters also used for Pitch & Yaw
  - 4 0.2-lbf thrusters for Roll control
- **C&DH: RAD6000 processor**
- **Telecom:**
  - Cassini Deep Space Transponders
  - 15W RF SSPA's
  - One 1.3m Tx/Rx HGA, 1 Tx-only MGA, 1 Rx-only LGA
  - UHF 10 Watt RF system for 2-way communication with Lander
- **Power:**
  - Single, 3 panel GaAs/Ge solar array, 2 axis gimballed
  - NiH2 CPV batteries
- **Thermal Control:**
  - Passive: louvers, MLI, Kapton, paints, dedicated radiators
  - Thermostatically controlled and computer controlled heater circuits
- **Propulsion:**
  - Biprop system for MOI only
  - Hydrazine TCM thrusters [4 5-lbf thrusters] for all other maneuvers
- **Structure: Composite facesheets on Aluminum honeycomb.**

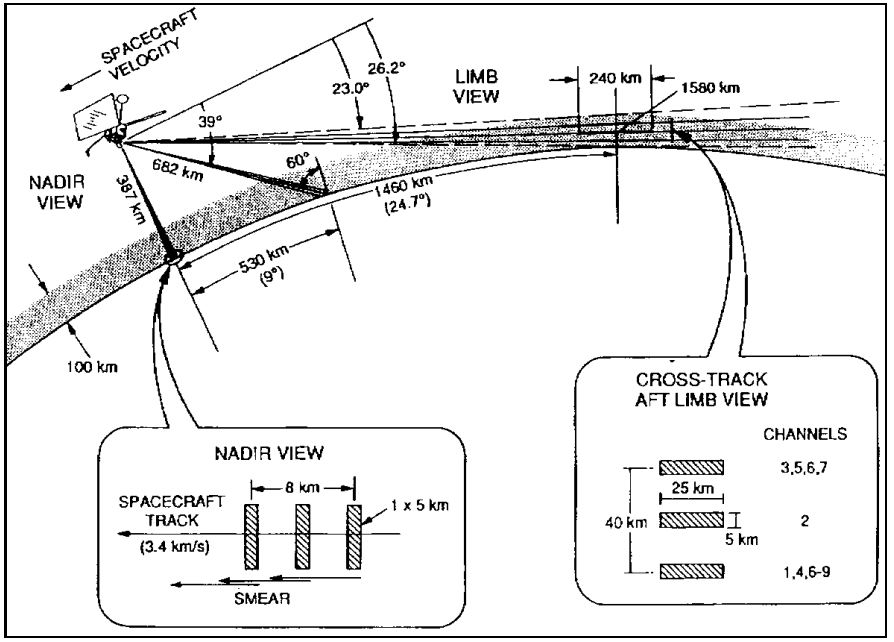


MCO PAYLOAD

Orbiter Science and Equipment Decks



PMIRR Fields of View



- **Pressure Modulator Infrared Radiometer [PMIRR]**
  - Multispectral limb and nadir scanning atmospheric sounder
    - » Provides vertical profiles of atmos. temp, dust, water vapor & clouds, quantifies surface radiative balance
  - Radiator door deployed upon achieving mapping orbit
  - Nominal FOV includes aft limb. Can also view out of s/c orbit plane.
  - Vertical resolution = 5 km
- **Mars Color Imager (MARCI)**
  - Combined nadir pointed pushframe Wide Angle [WA] and Medium Angle [MA] cameras, totaling 2 kg
  - WA camera: FOV = 140˚, 7 spectral bands [5 visible, 2 UV]; MA camera: FOV = 6˚, 10 spectral channels
  - Imaging: Approach imaging, daily global Mars images with WA, monitoring of surface changes with MA during intervals with high data rates.

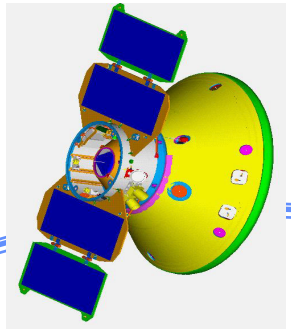
MCO MISSION PHASES

- **Launch, Boost and Initialization**
  - **Launch: Liftoff - 20 hours to liftoff**
  - **Boost and Initialization: Liftoff until initial acquisition by DSN**
- **Interplanetary cruise**
  - **From initial acquisition through MOI sequence start**
  - **Includes post-launch checkout, midcourse maneuvers, and science instrument calibrations**
- **Mars Orbit Insertion Phase (MOI)**
- **Aerobraking**
- **MPL Relay Support**
- **Mapping**
- **Post-Mapping Relay**

MPL MISSION OVERVIEW

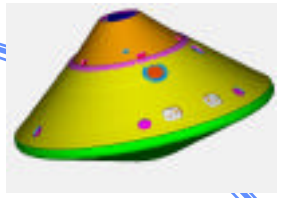
Cruise

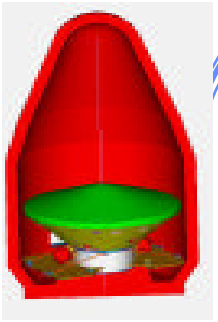
- Thruster Attitude Control
- 4 Trajectory Correction Maneuvers, Site Adjustment maneuver at L+180d, Contingency maneuver at Entry - 7 hr
- 11 Month Cruise
- Near-simultaneous tracking w/ Mars Climate Orbiter or MGS during approach



Entry, Descent, & Landing

- Arrival 12/3-17/99
- Jettison Cruise Stage
- Microprobes sep from Cruise Stage
- Hypersonic Entry (7 km/s)
- Parachute Descent
- Propulsive Landing
- Descent Imaging [MARDI]



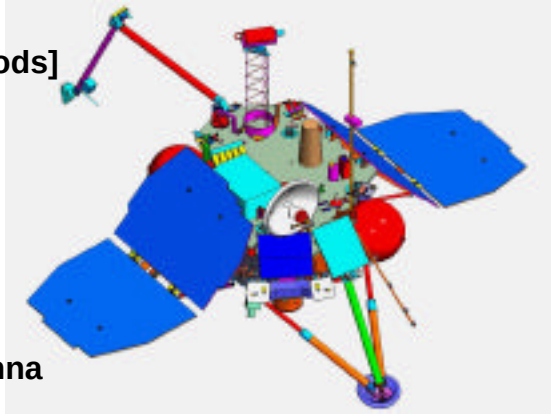


Launch

- Delta 7425
- Launch 1/3-27/99
- 576 kg Launch Mass

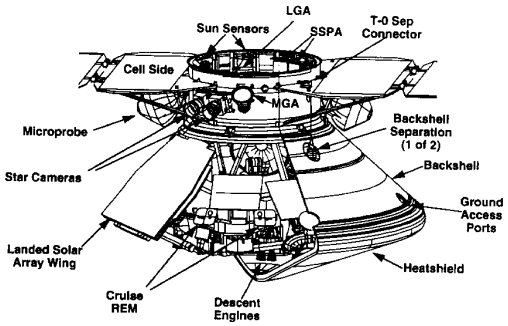
Landed Operations

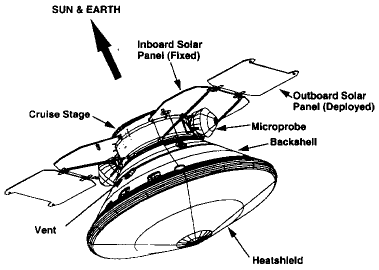
- 74°-76° South Latitude [Primary & 2ndary launch periods]
- Ls 256° (Southern Spring)
- 90 Day Landed Mission
- MVACS, LIDAR Science
- Data Relay via Mars Climate Orbiter or MGS
- Commanding via Mars Climate Orbiter or Direct-to-Earth high gain antenna



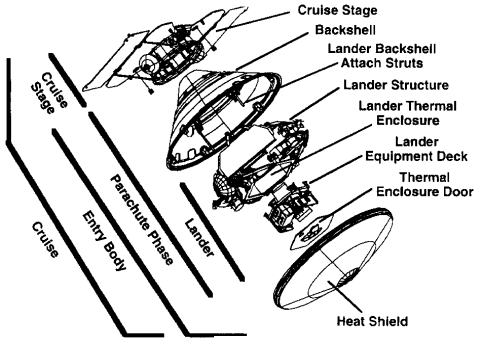
MPL FLIGHT SYSTEM

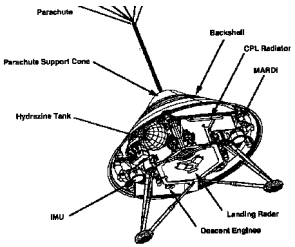
- **Cruise Stage:**
  - Redundant star cameras, sun sensors
  - Two solar arrays: 2.6 m^2 total area
  - X-Band transmit/receive horn MGA, 1 patch LGA, redundant pair of solid state power amplifiers (SSPA's)
  - 3 axis control: redundant IMU's, 4 reaction engine modules [REM's] located on Lander.
    - » Each contains 1 aft-facing 5-lbf TCM thruster and 1 1-lbf RCS thruster [canted outward 20° and aft 15°].



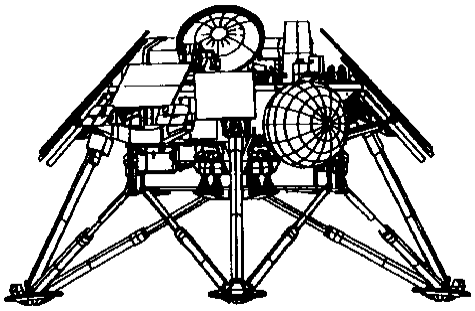


- **EDL System:**
  - 2.4 m diameter heatshield [ablator] based on MPF design
  - Ballistic coefficient 58 - 62 kg/m^2 , MPF parachute design.
  - Mortar parachute deployment based on IMU velocity estimate
  - Heatshield separates after parachute deployment, landing legs are deployed, descent engines are warmed with short pulses
  - MARDI starts operating just prior to heatshield separation
  - Fight software guidance algorithms determine optimum time for lander release & start of powered descent phase.





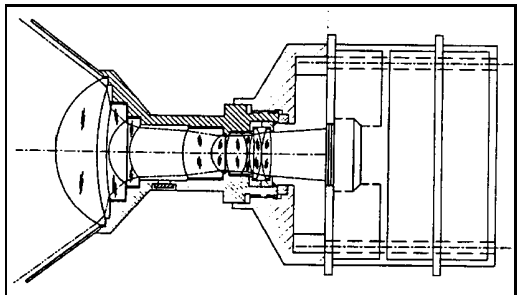
- **Propulsion System:**
  - 2 diaphragm tanks [64 kg total hydrazine capacity] used for translational and rotation ΔV for all mission phases.
  - Pressure regulated with He pressurant
  - Final Descent:
    - » Doppler radar provides altitude & velocity estimates
    - » Twelve pulse modulated 266 N engines, 3 groups of 4 engines each
    - » 2.4 m/s constant vel terminal descent phase starts 12 meters above surface
    - » Engines cut off when any of the footpads touch the surface
    - » AACS subsystem controls landed orientation to place X axis within 5° of desired azimuth [45° West of North]



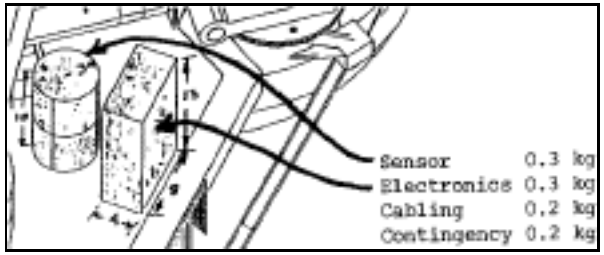
Terminal Descent Configuration

MPL PAYLOAD

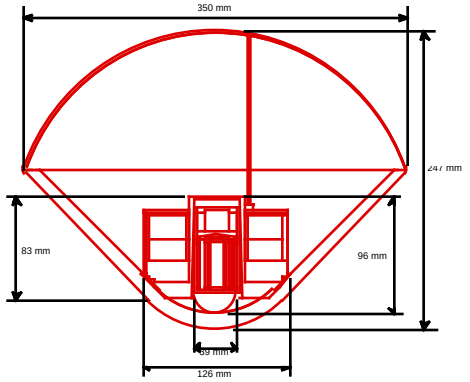
- **Mars Descent Imager (MARDI)**
  - Images taken starting just before heatshield jettison, & continue until landing.
  - Megapixel, electronically shuttered CCD will take panchromatic images of the landing site at 1.25 mrad/pixel.
  - 10 1000x1000 pixel images will be taken, covering areas from 9 km to 9 m across at resolutions of 7.5 m to 9 mm per pixel pair.
  - Built by Malin Space Science Systems, Dr. Michael Malin Principal Investigator.



- **LIDAR [Light Detection and Ranging]**
  - Upward viewing lidar mounted on the Lander deck.
  - Provided by Space Research Institute (IKI) [Russian Academy of Science] under sponsorship of the Russian Space Agency (RSA). S. Linkin PI
  - LIDAR transmitter uses a pulsed GaAlAs laser diode
  - 2 sounding modes:
    - Active sounding: light pulses emitted and thier return timed to locate and characterize ice and dust hazes below 2-3 km
    - Acoustic device [microphone]

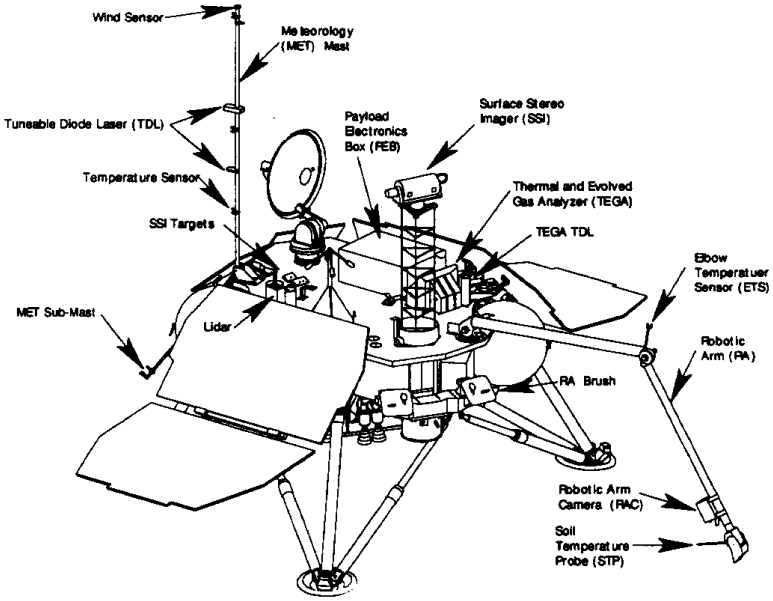


- **NEW MILLENIUM MICROPROBES**
  - 2 probes separate from cruise ring 15 -20 sec after cruise stage jettison
    - Separation turns on the probes.
    - Temperature, accelerometer, engineering data recorded during descent.
  - Impact ~7 min later at ~180 m/s. Aeroshell destroyed on impact.
    - Forebody penetrates > 0.3 m
    - Aft body containing batteries, pressure sensor, sun detector, and antenna remains on surface
  - Immediately after impact, a soil sample is acquired
  - Begin listening for MGS beacon. All data relayed via MGS.
  - Primary Mission: 2 Sols, Extended Mission: 30-45 Sols
  - Experiments: Soil thermal conductivity, Atmospheric pressure, Water detection



MPL PAYLOAD (cont'd)

- **Stereo Surface Imager [SSI]**
  - Mast-mounted stereo color imager, clone of PF IMP
    - » Multispectral capability [0.4 - 1.1 microns]
    - » Dual optics focusing on single CCD
  - Provides panoramas of site and imaging support for other payload elements, especially the Robotic Arm and TEGA
  - Images magnetic targets on deck
    - » Magnetic characterization of surface material
  - Narrow-band imaging of Sun
    - » Line of sight optical depths of aerosols
    - » Slant column water vapor abundances
- **Robotic Arm [RA]; Robotic Arm Camera [RAC]**
  - 2-meter arm with articulated end member, camera, and temperature probe
  - Digs trenches, to acquire samples of surface and subsurface materials, and support operations of the RAC
  - RAC images surface and subsurface to reveal fine-scale layering if present and characterize fine-scale texture of the samples and trench sides

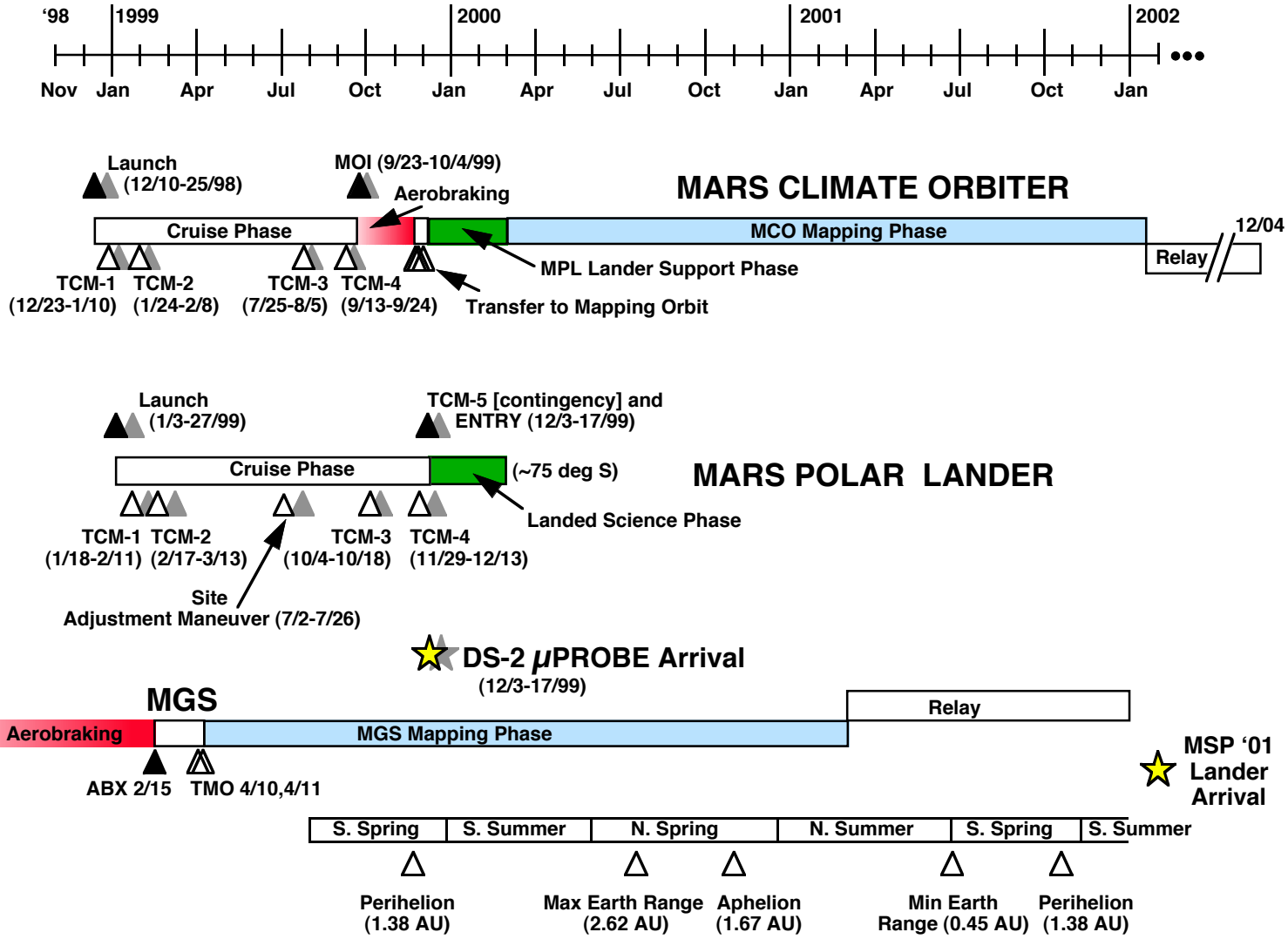


- **Meteorological Package [MET]:**
  - Mounted on 1.2-m mast: wind (speed and direction) sensor, temperature sensors, and Tunable Diode Lasers (TDL) which measure water vapor amounts and specific isotopes of water and carbon dioxide.
  - Secondary mast (0.9 m) is attached to the main MET mast: wind speed & 2 temperature sensors near the surface saltation layer.
  - Pressure sensors are mounted within the spacecraft.
  - On the surface, MET sensors are read at periodic intervals, as power permits.
- **Thermal and Evolved Gas Analyzer [TEGA]:**
  - Uses differential scanning calorimetry (DSC) combined with gas-specific sensors to determine the concentrations of ices, adsorbed volatiles and volatile-bearing minerals in surface and subsurface samples acquired and imaged by the Arm.
  - **Operation:** RA deposits the sample in a receptacle, which is then mated with a cover to form the oven; Evolved gases are wafted to sensors which quantify the rate of discharge of oxygen, carbon dioxide and water vapor. Once used, the ovens cannot be used again. Eight surface [soil] samples can be analyzed.

MPL MISSION PHASES

- **Launch, Boost and Initialization**
  - **Launch: Liftoff - 18 hours to liftoff**
  - **Boost and Initialization: Liftoff until initial acquisition by DSN**
- **Interplanetary Cruise**
  - **From initial acquisition through EDL sequence start**
  - **Includes post-launch checkout, midcourse maneuvers, and science instrument calibrations**
- **Entry, Descent, and Landing (EDL)**
- **Landed Operations**

MS '98 MISSION TIMELINE



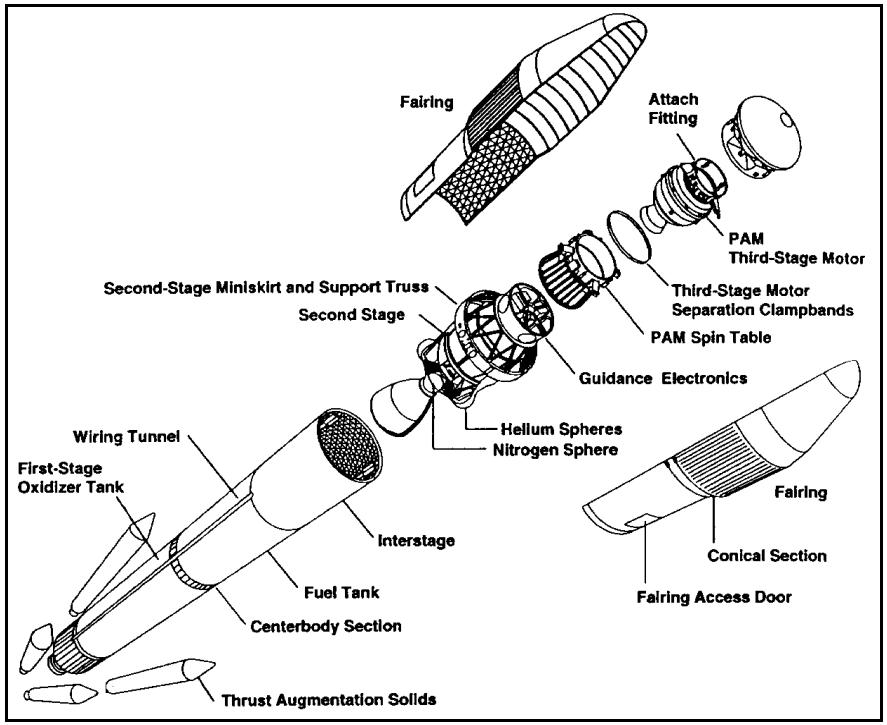
LAUNCH/CRUISE DSN COVERAGE

- **MCO**
  - **Continuous coverage scheduled through L+7 days**
  - **12 hr/day coverage scheduled from L+7 to L+30 days**
  - **4 hr/day coverage from L+30 days to MOI-30 days**
  - **Near-simultaneous coverage with MGS from MOI-30 to MOI**
- **MPL**
  - **Same schedule as for MCO from launch to L+30 days (DSN to monitor during off-track periods)**
  - **Same schedule as for MCO from L+30 days to EDL-45 days**
  - **Near-simultaneous coverage with MCO/MGS from EDL-45 to EDL**
- **Each Spacecraft Equipped with Cassini Transponder (identical carrier/subcarrier frequencies)**
- **Integrated DSN Scheduling Performed within MSOP**

LAUNCH/INITIAL ACQUISITION

LAUNCH VEHICLE

- **Orbiter and Lander each separately launched on Boeing Delta II/7425.**
  - Procured via MedLite Launch VehIcle contract
  - Four solid [GEM] version of Delta II
  - 9.5 ft fairing
  - Spin-stabilized Star 48 upper stage
    - » Nutation Control System
    - » Yo-yo despin device



- **Launch Opportunties.**
  - Two/day (orbiter), One/day (lander)
  - 93˚ and 105˚ flight azimuths
  - Near-instantaneous launch windows
  - Short coast ascent trajectories

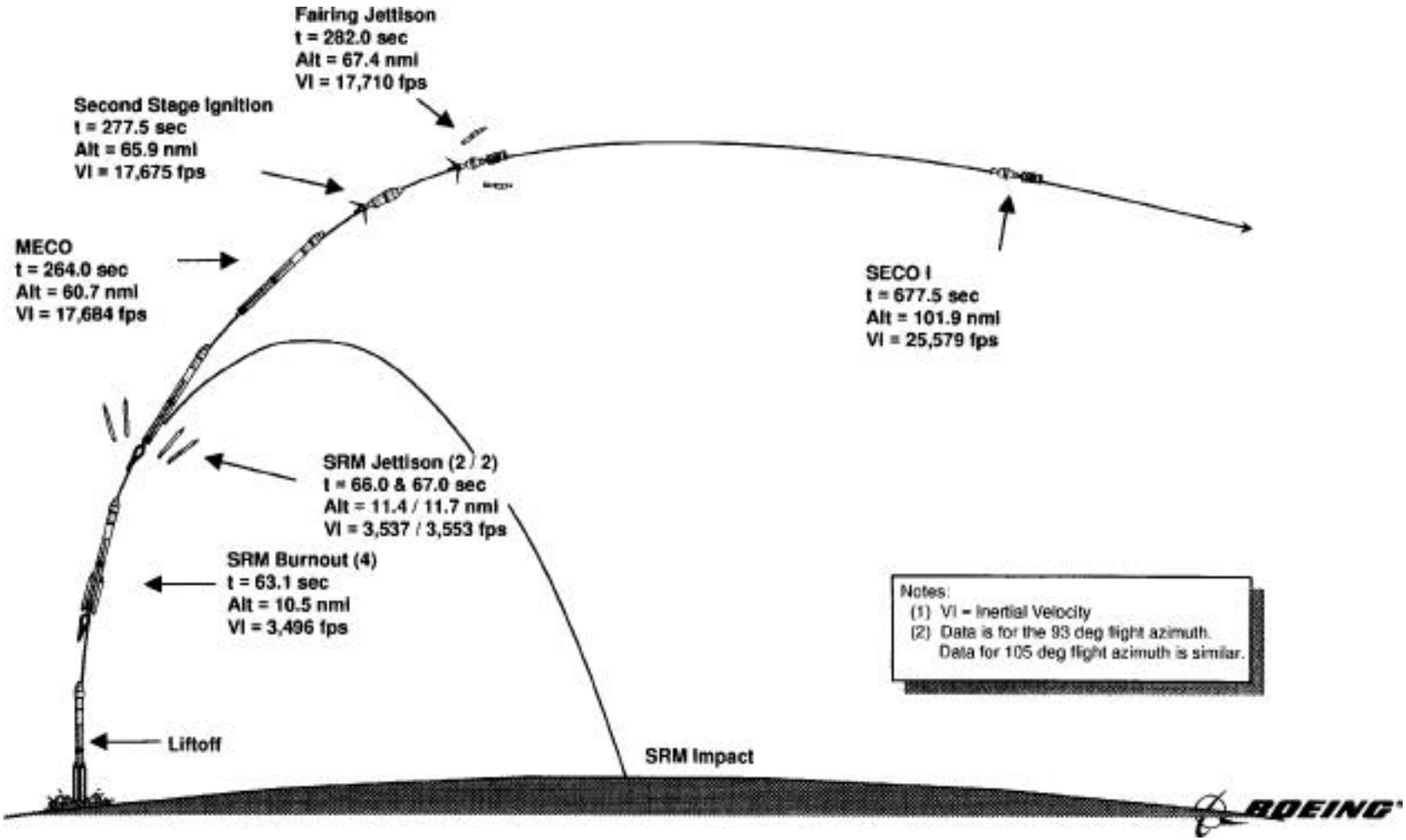
- **Capability:**
  - **Project requires 2nd Stage probability of commanded shutdown [PCS] ≥ 95%**
    - » Orbiter: **629** kg injected mass.
    - » Lander: **576** kg injected mass.
  - Launch vehicle performance exceeds this requirement with PCS ≥ 99.7%

- **The Orbiter and Lander launches must occur at least 9 days apart.** Two pads are needed to support this requirement.

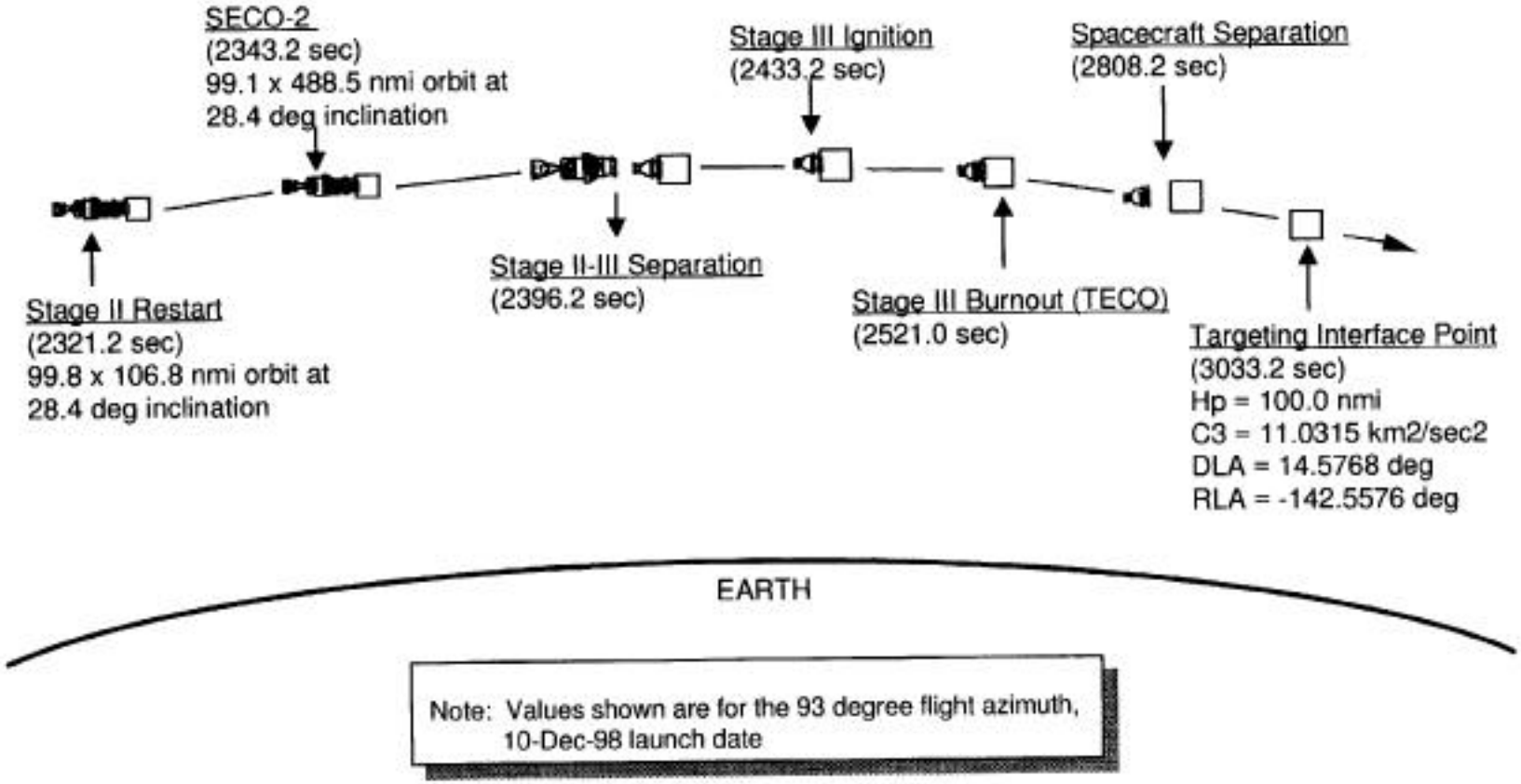
MCO LAUNCH/ARRIVAL STRATEGY

- **Objective: Achieve Arrival Conditions Allowing Completion of Aerobraking Prior to MPL Arrival**
- **16 Day Launch Period: 12/10/98 - 12/25/98**
  - **Primary Period: 8 days: 12/10/98 - 12/17/98**
    - **capture orbit period of 13-14 hr**
    - **>95% probability that Orbiter completes aerobraking 14 days prior to MPL arrival**
  - **Secondary Period: 6 days: 12/18/98 - 12/23/98**
    - **capture orbit period of 14-16 hr**
    - **some erosion of 14 day aerobraking schedule margin**
  - **Contingency Period: 2 days: 12/24/98 - 12/25/98**
    - **capture orbit period of 16-17 hr**
    - **further erosion of aerobraking schedule margin**
    - **use MGS or direct-to-Earth X-band link if needed for MPL support**

DELTA/MCO LAUNCH/ASCENT



DELTA/MCO INJECTION

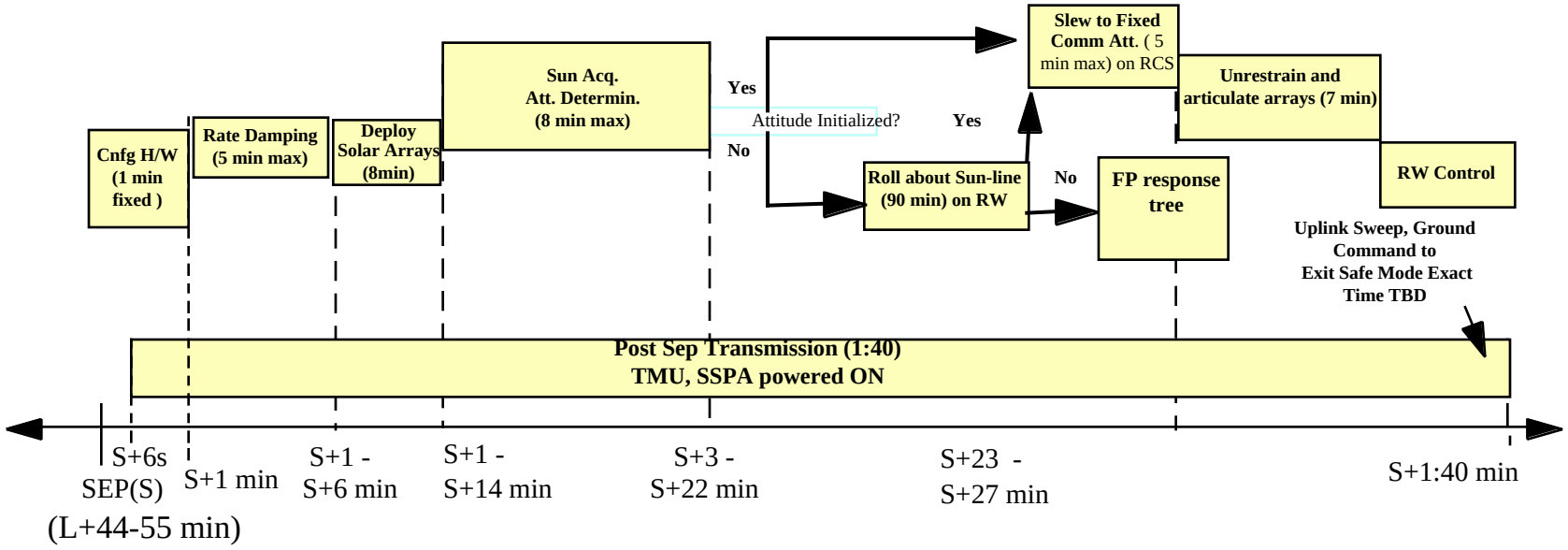


Note: Values shown are for the 93 degree flight azimuth, 10-Dec-98 launch date

BOEING

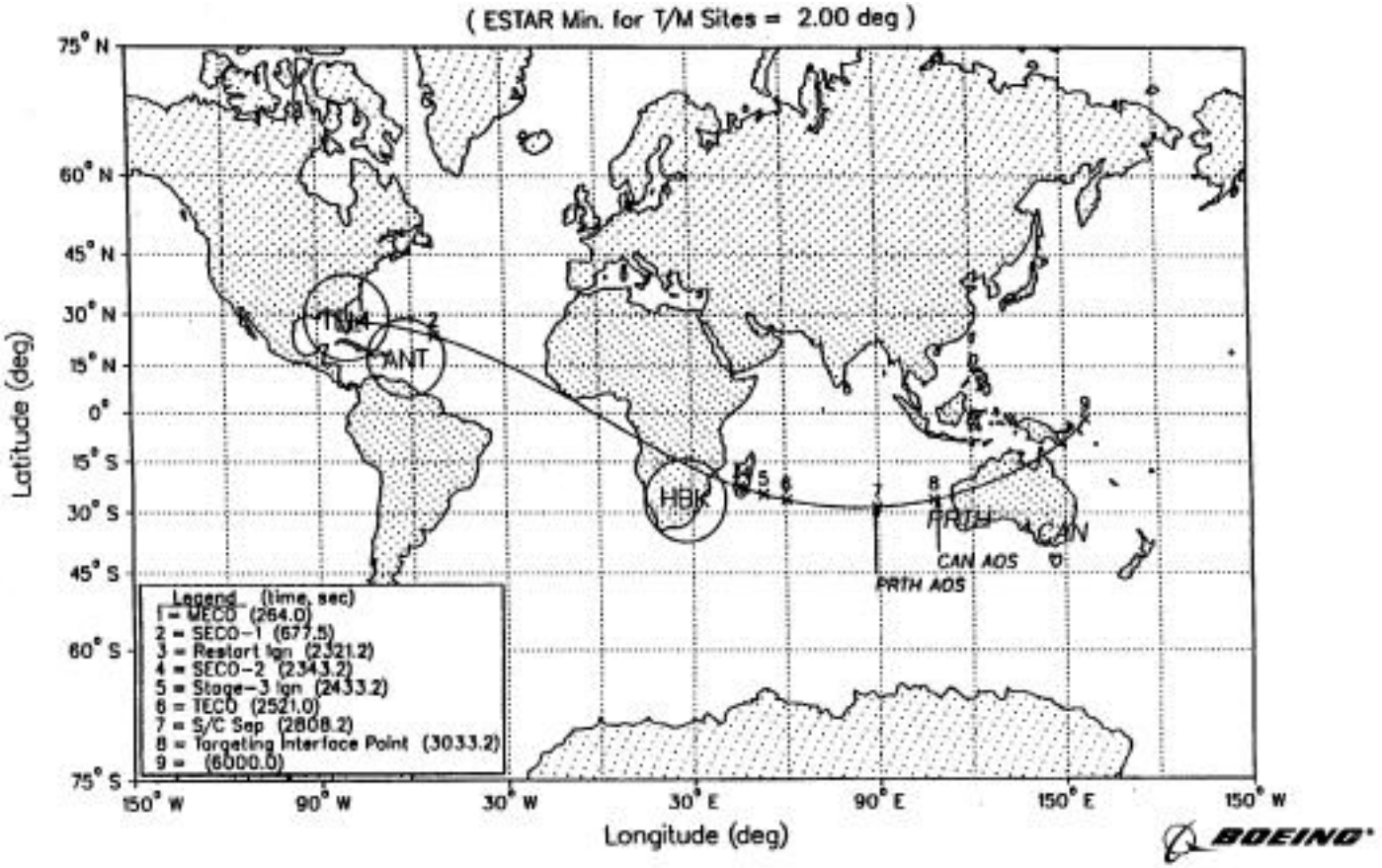
MCO INITIALIZATION TIMELINE

Spacecraft Initialization (MGA XMIT, LGA RCV)



- **MCO Capable of Continuous X-band Transmission**
  - **Capability identified via recent analysis of thermal/vacuum test data**
  - **Change request initiated to leave SSPA on continuously for first week**
  - **No time-critical commanding planned on nominal timeline**

DELTA/MCO ACQUISITION COVERAGE



- **Ground Track for 10-Dec-98 Launch on 93 deg Flight Azimuth**
- **Initial Acquisition over Canberra within 8 min of Separation**
  - **DSS-46 (26 m with X-band acquisition aid) and DSS-45 (34 m HEF)**
  - **Portable X-band receiver recording planned prior to Canberra rise**

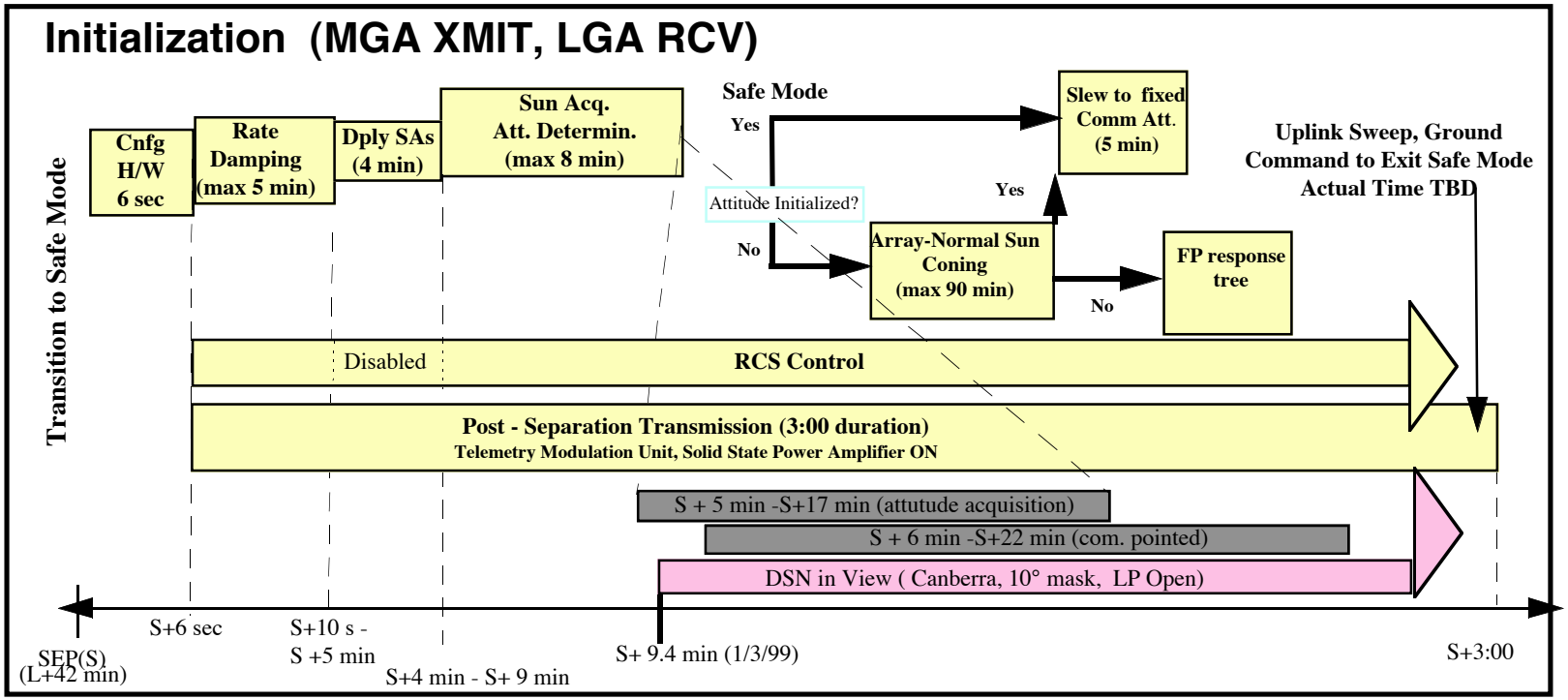
MPL LAUNCH/ARRIVAL STRATEGY

- **Objective: Reach Layered Terrain in South Polar Region**
- **25 Day Launch Period: 01/03/99 - 01/27/99**
  - **Primary Period: 8 days: 01/03/99 - 01/10/99**
    - **target latitude of 75 deg S**
    - **arrival on 12/03/99 (late spring in Southern hemisphere)**
    - **entry velocity < 6.9 km/s**
  - **Secondary Period: 6 days: 01/11/99 - 01/16/99**
    - **75 deg S target latitude maintained**
    - **arrival date begins to move later**
    - **entry velocity allowed to increase**
  - **Contingency Period: 11 days: 01/17/99 - 01/27/99**
    - **target latitude moves to 73 deg S (end of contingency period)**
    - **latest arrival date of 12/17/99 (end of contingency period)**
    - **entry velocity held constant at 7.07 km/s**

DELTA/MPL LAUNCH/ACQUISITION

- **Launch/Ascent**
  - **Ascent trajectory very similar to Delta/MCO**
  - **Time of liftoff and ascent timeline also similar**
- **Injection**
  - **Spacecraft separation occurs approximately 270 s earlier relative to Delta/MCO ascent/injection timeline**
- **Acquisition Coverage**
  - **Initial acquisition also over Canberra**
  - **Same DSN assets scheduled as for MCO (DSS-45 and -46)**
  - **Spacecraft in view within 10 min of separation**

MPL INITIALIZATION TIMELINE



- **MPL X-band Transmit Capability Not Yet Verified**
  - **Awaiting results of 2nd cruise thermal/vacuum test 3-7 Sep. 98**
  - **Post-test analysis to establish max. on/min. off SSPA cycle (Sep. 28)**
  - **Will incorporate test results into acquisition and early cruise plans**

MCO/MPL ACQUISITION TIMELINES

- MCO Timeline (hrs)
- L-20: power up
- L-12: start mobile service tower rollback
- L-6: rollback complete
- L-20 min: go/no-go for launch
- LAUNCH
- L+44 min: Star-48 separation
- L+52 min: initiate acquisition sweep at DSS-45
- L+1: one-way acquisition
- L+3: two-way acquisition
- L+4: uplink no-op command
- L+2 days: exit safe mode

- MPL Timeline (hrs)
- L-18: power up
- L-12: power down; start rollback
- L-6: rollback complete
- L-4: power up and tlm check
- L-30 min: power up and tlm check; go/no-go for launch
- LAUNCH
- L+42 min: Star-48 separation
- L+52 min: initiate acq sweep
- L+1: one-way acquisition
- L+3: two-way acquisition
- L+4: uplink no-op command
- L+8: exist safe mode and start 1st cruise sequence

CONTINGENCY SCENARIOS

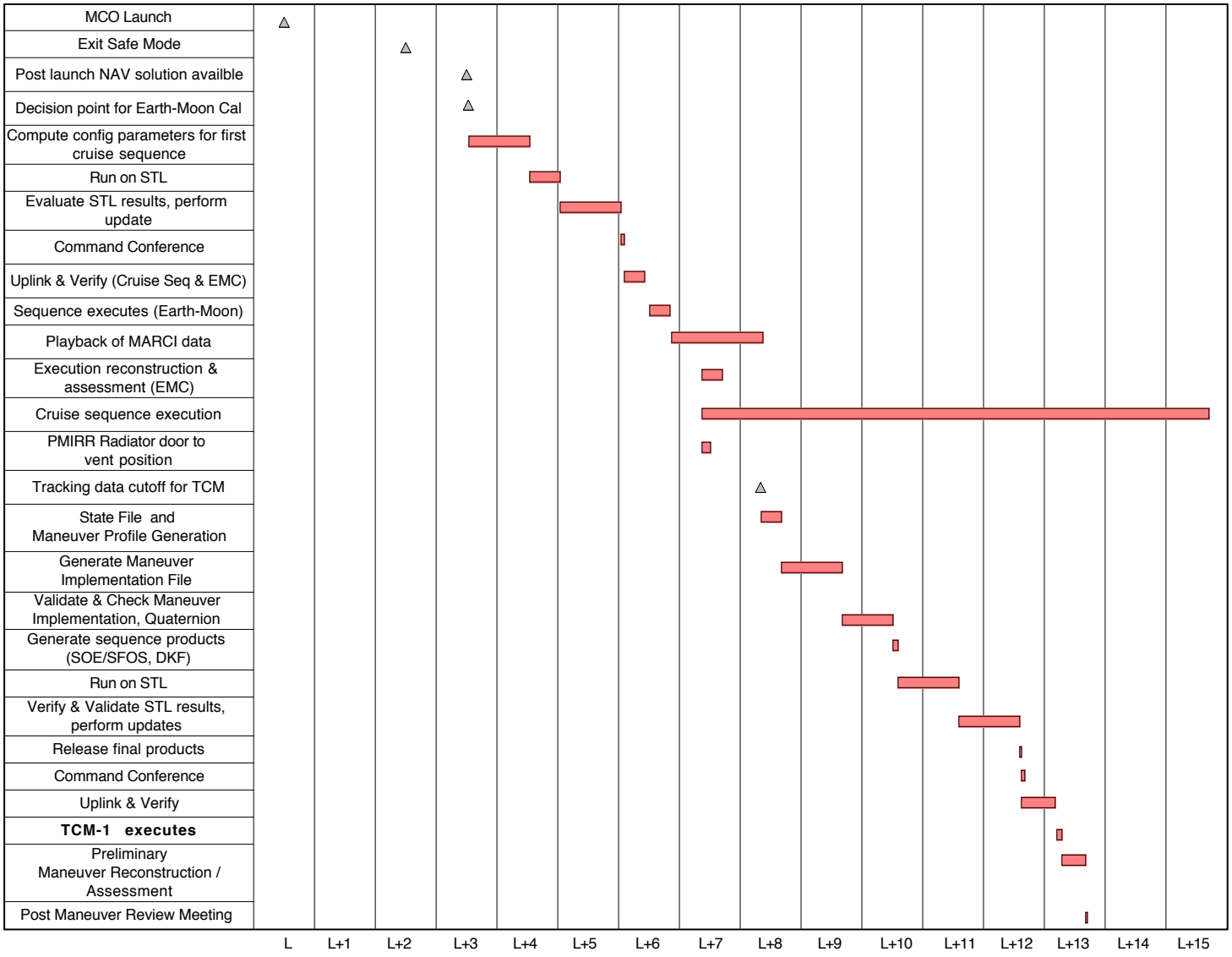
- **Several Contingency Scenarios Under Development**
  - **Set of scenarios to be exercised in pre-launch test/training**
    - **means of diagnosis**
    - **appropriate responses**
    - **prepared commands and sequences**
  - **Additional set of scenarios (difficult to pre-plan) for which some planning done, but no pre-launch training**
- **First-Tier Scenarios (for Sep.-Nov. test and training period)**
  - **Downlink Problems at Acquisition**
  - **Solar Array Deployment Anomaly**
  - **Substandard Attitude Determination Performance**
- **Second-Tier Scenarios**
  - **Stuck thruster or significant outgassing**
  - **Power/Thermal subsystem anomaly**
  - **Diagnosis of any string swap detected post-launch**

INTERPLANETARY CRUISE PHASE

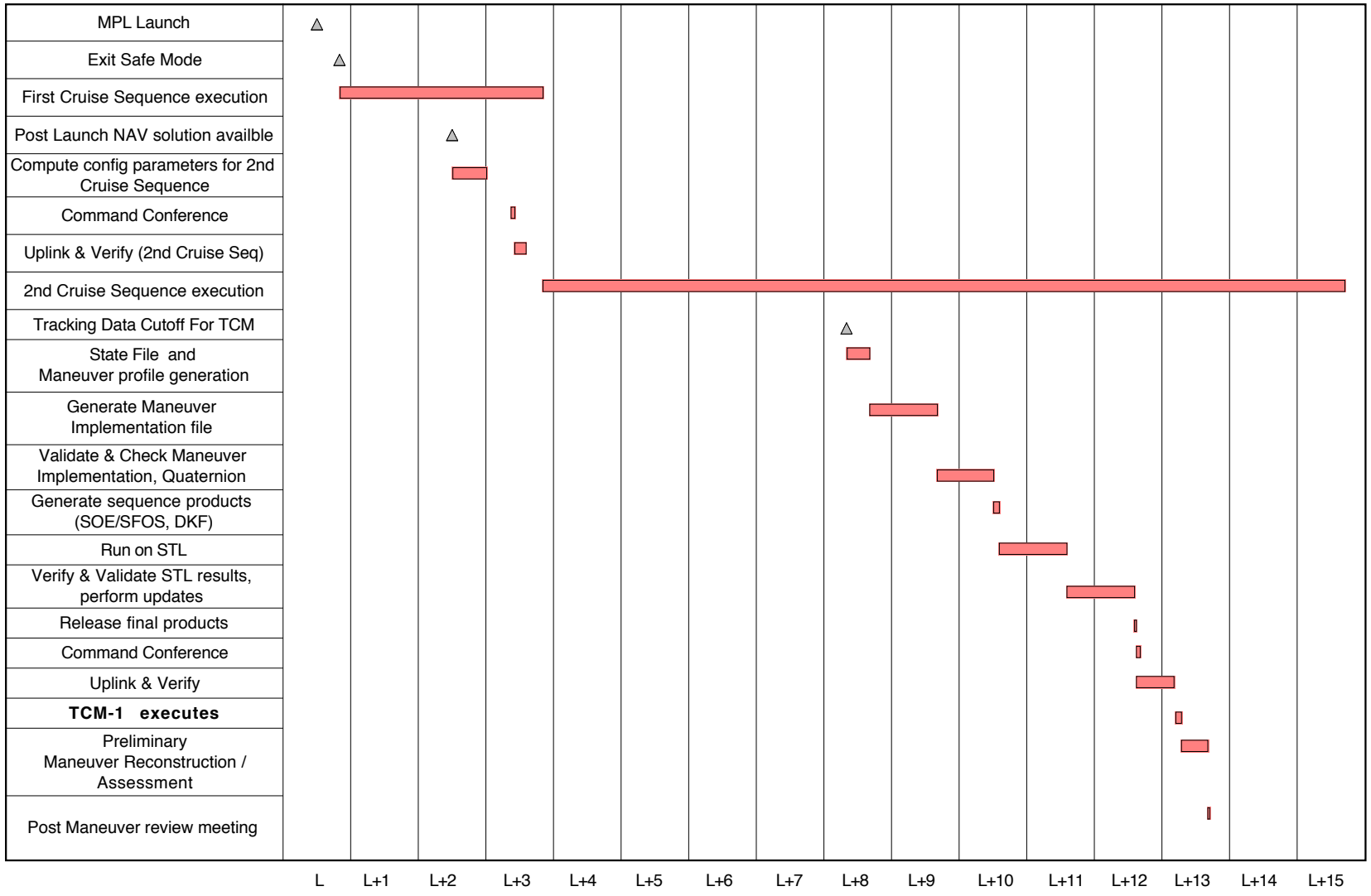
CRUISE PHASE OVERVIEW

- **Planning Guidelines and Approach**
  - **Minimize ops effort to support needed cruise operations**
    - **spacecraft health and monitoring**
    - **engineering subsystem and instrument checkout/calibration**
  - **Activities scheduled such that flight team has no more than one intense activity at any time between MGS, MCO, MPL**
  - **Confine science instrument ops to brief, specified episodes**
    - **two one-week checkout periods each for MCO and MPL**
    - **70 m antenna coverage arranged for lander checkout periods**
- **Sequencing Strategy**
  - **Long duration (4-6 week) engineering housekeeping sequences to support DSN contact schedule**
  - **Science checkout and specific engineering sequences (e.g., maneuvers) run in parallel with housekeeping sequence**
  - **Maximize reuse of sequence templates**

MCO EARLY CRUISE TIMELINE



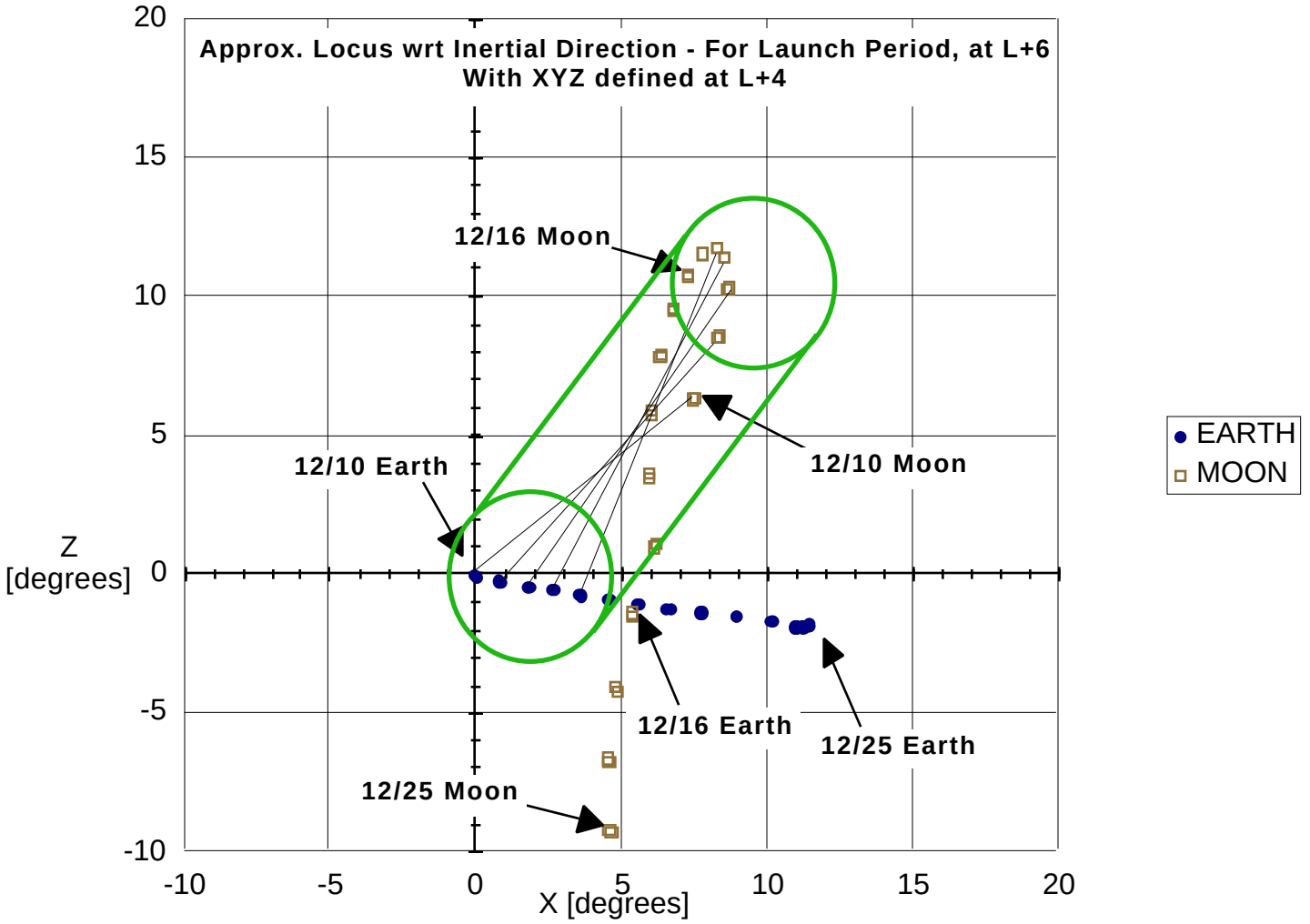
MPL EARLY CRUISE TIMELINE



MARCI EARTH/MOON CALIBRATION

- **Imaging of Earth/Moon System Requested by MARCI**
  - **Targets with known color and albedo variation**
  - **Provide reference points for new MARCI color filters**
  - **Requested timing is between L+4 and L+7 days**
- **Criteria Established for Implementation**
  - **Sequence (modified midcourse maneuver) built and verified prior to launch for single rotational maneuver at L+6 days**
  - **Sequence will not be attempted after 14 Dec. 98**
  - **pre-launch Operational Readiness Test must be completed**
  - **Spacecraft must be healthy to load sequence**
    - **attitude determination and control**
    - **power and thermal control**
    - **uplink/downlink**
    - **flight S/W**
  - **Sequence must be uplinked successfully**

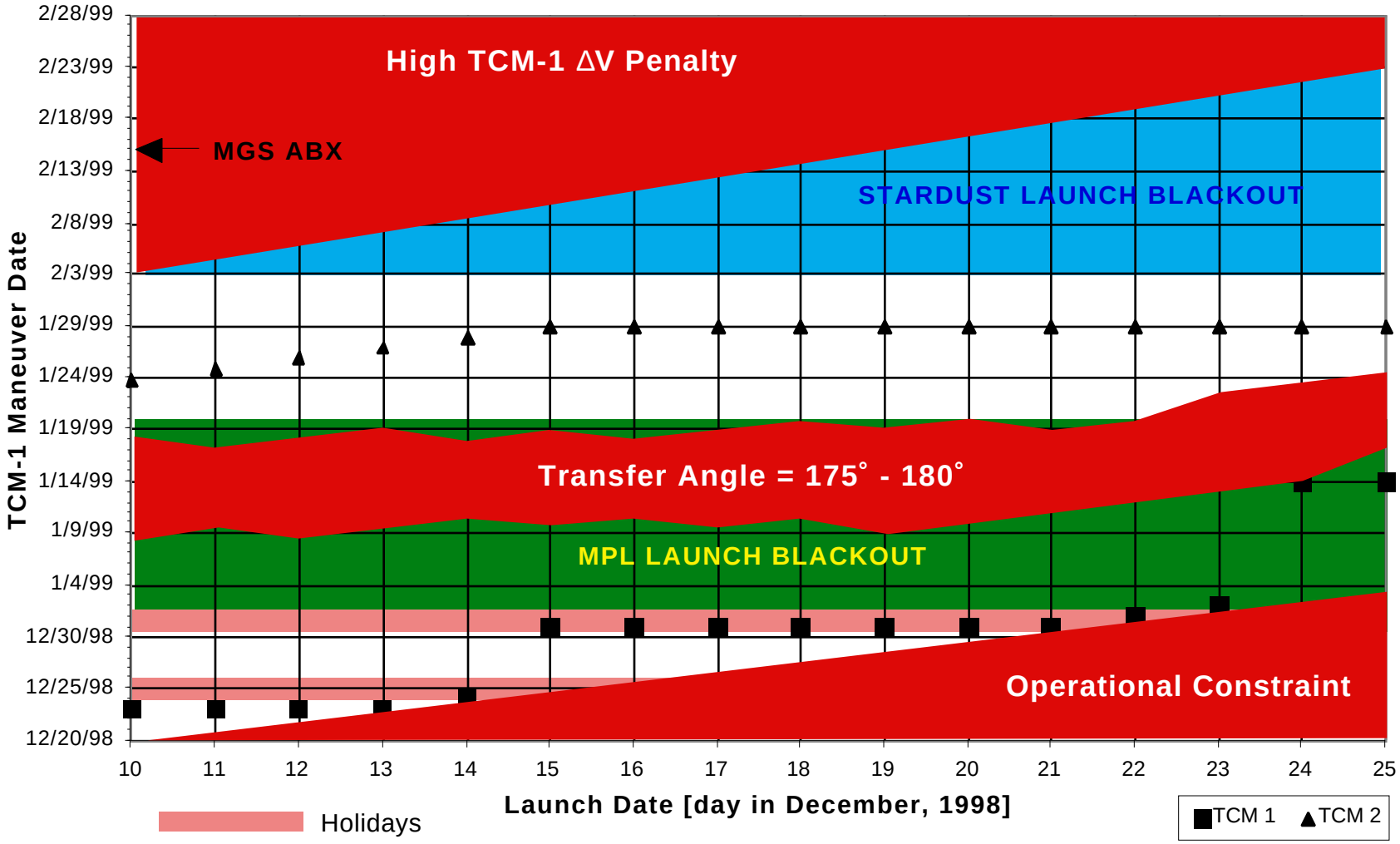
EARTH/MOON VIEWING GEOMETRY



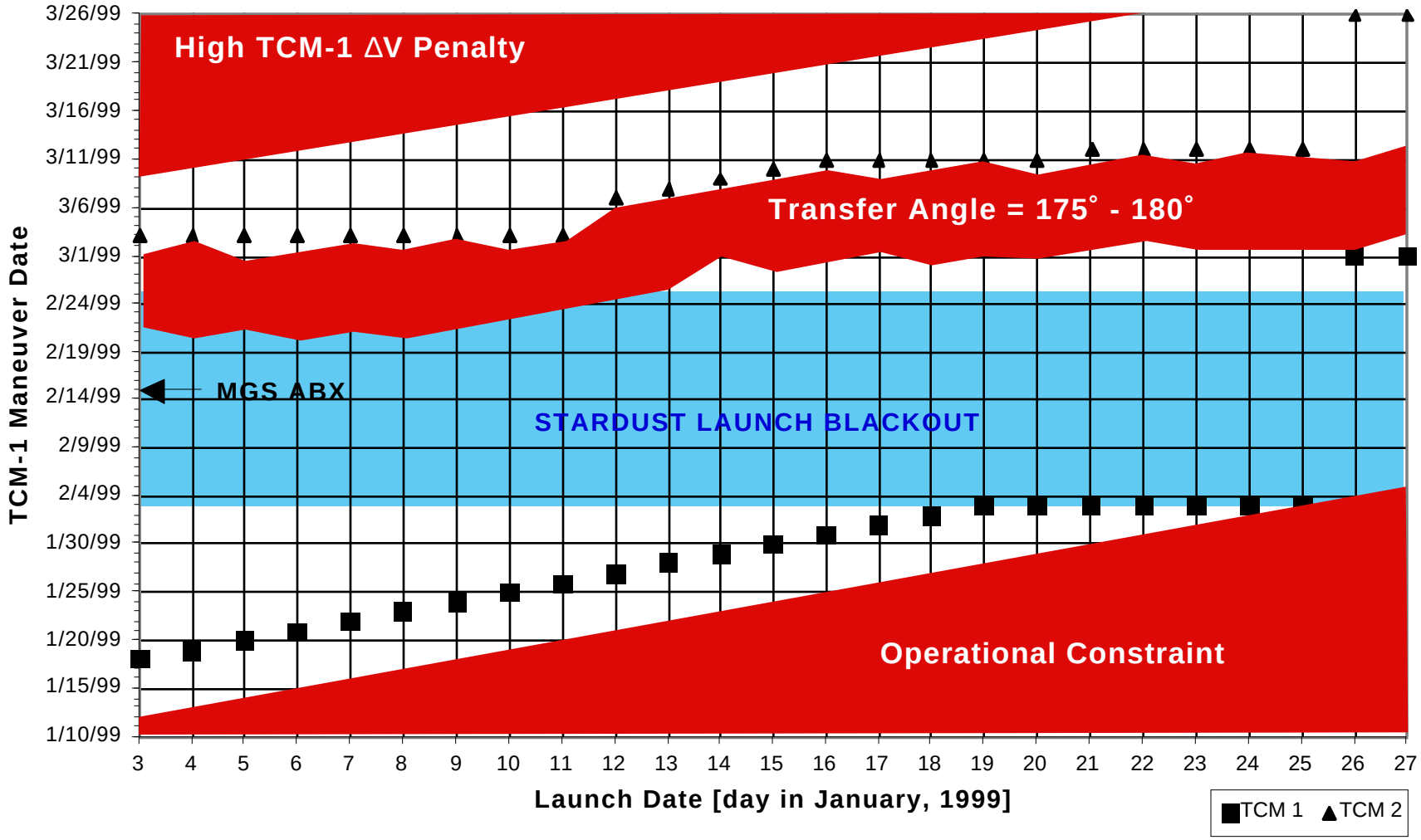
MIDCOURSE GUIDANCE LOGISTICS

- **Guidelines for Trajectory Correction Maneuvers (TCM's)**
  - **MCO**
    - **perform TCM-1 prior to MPL launch if possible**
    - **if not possible, delay TCM-1 until after MPL TCM-1**
  - **MPL**
    - **perform TCM-1 prior to Stardust launch if possible**
- **Constraints**
  - **MCO**
    - **MPL launch window**
    - **time period where transfer angle to Mars near 180 deg**
    - **Stardust launch window**
    - **onboard propellant load**
  - **MPL**
    - **Stardust launch window**
    - **time period with near-180 deg transfer angle**
    - **onboard propellant load**

MCO MANEUVER PLANNING GUIDE

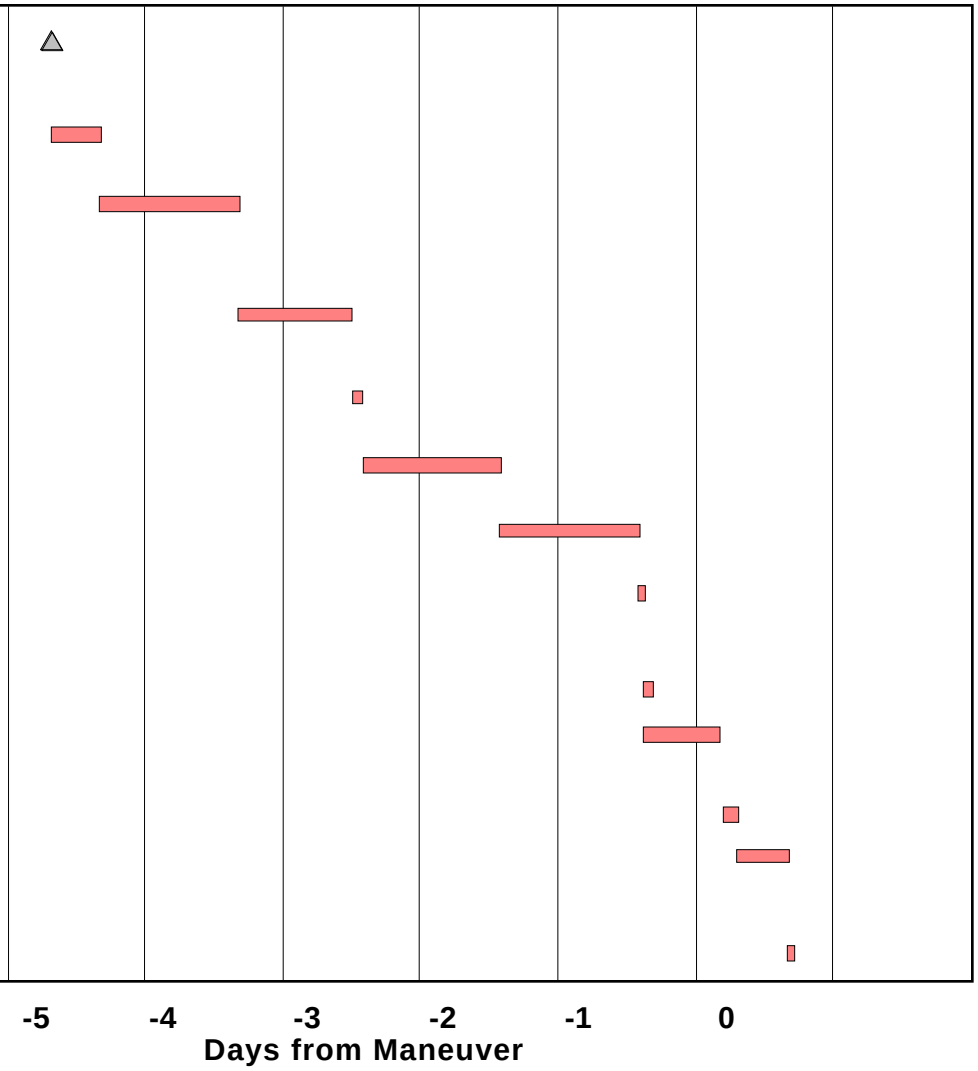


MPL MANEUVER PLANNING GUIDE



MANEUVER DESIGN TEMPLATE

	Dur in Hrs.
Tracking Data Cutoff	
State File and Maneuver Profile Generation	8.00
Generate Maneuver Implementation File	24.00
Validate & Check Maneuver Implementation, Quaternion	20.00
Generate sequence products (SOE/SFOS, DKF)	2.00
Run on STL	24.00
Verify & Validate STL results, Submit updates	24.00
Release final products	1.00
Command Conference	1.00
Uplink & Verify	13.00
TCM-1 executes	2.00
Preliminary Maneuver Reconstruction / Assessment	9.00
Post Maneuver Review Meeting	1.00



CONTINGENCY SCENARIOS

- **Early Cruise Contingency Planning Under Development at Two Levels**
  - **Strategic**
    - **MCO maneuver planning guide**
    - **MPL maneuver planning guide**
    - **maneuver design/implementation template**
    - **these tools provide basis establishing maneuver execution dates given uncertainty in MCO/MPL launch dates, mission events, etc.**
  - **Tactical**
    - **rotational maneuvers (MARCI Earth/Moon and TCM's)**
      - **not possible to ensure radio contact during entire maneuver**
      - **plan under development for loss of contact during slew maneuver and for no resumption of contact after slew**
    - **no contact at initiation of tracking pass**
    - **safe mode diagnosis and recovery**

FLIGHT OPERATIONS PLANNING

MSOP TEAM COMPOSITION

- **Flight Team Staffing**
  - **Combination of MGS team and MS ‘98 development personnel**
  - **Mix of personnel performing multi-mission support and key personnel dedicated to specific missions**
  - **MCO/MPL/MGS assignments on a team-by-team basis**
- **Team Augmentation for MS ‘98 Flight Operations**
  - **Spacecraft**
    - **Adding 12 MS ‘98 development personnel**
    - **Team size approximately 30 now versus 20 during MGS cruise**
  - **Mission Planning and Sequencing**
    - **Adding one person from MS ‘98 development**
    - **Existing team members supporting MS ‘98 system test**
  - **Navigation**
    - **Adding one person from MS ‘98 development**

PLANS AND PROCEDURES

- **Operations Plans/Procedures Developed by Mission Phase**
  - **Launch/acquisition through transition to cruise**
  - **Midcourse maneuver**
  - **MARCI Earth/Moon calibration imaging**
- **Small, Cross-Discipline Teams to Develop**
  - **Teams formed from MSOP teams to get mix of skills (adaptation of MPF "flight engineer" to MSOP)**
  - **Each team responsible for their phase end-to-end**
- **Each Team Develops Package for Their Phase Including**
  - **Detailed mission event timeline**
  - **Sequencing plan including stored sequences**
  - **Operational procedure(s)**
  - **Contingency plans and sequences**
  - **Operational Readiness Test plan**

SCENARIO DEVELOPMENT TEAMS

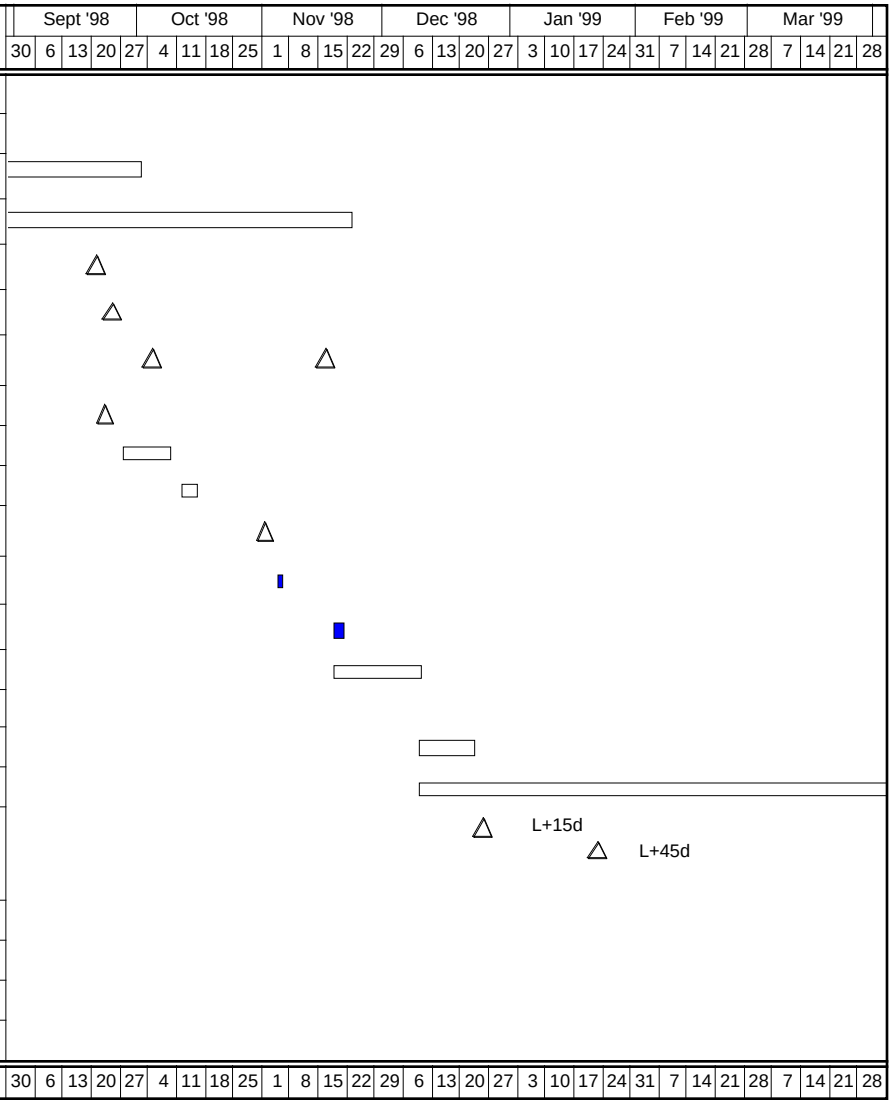
- **Inter-Scenario Planning and Coordination**
  - B. Arroyo (MP/S)
  - E. Brower (Ops Engr)
  - S. Lopez (MOS Sys Engr)
  - S. Thurman (FOM)
  - C. Whetsel (Proj Engr)
- **Launch/Cruise Transition**
  - C. Whetsel (lead)
  - B. Waggoner (MP/S)
  - S. Jolly (SCT)
  - B. Adams (SCT)
  - S. Toro-Allen (SCT)
  - D. Reece (NOPE)
- **Midcourse Maneuver**
  - P. Knocke (lead)
  - N. Mainland (MP/S)
  - S. Jolly (SCT)
- **MARCI Earth/Moon Cal**
  - B. Waggoner (lead)
  - P. Knocke (MP/S)
  - W. Sidney (SCT)
  - J. Callas (SCI)

OPERATIONAL READINESS TESTING

- **Operations Test and Training Approach**
  - **Assumes no opportunity for MPL test and training following MCO launch**
  - **Multi-disciplinary teams supervise test and training for their respective mission phases**
  - **Test and training outline (for each phase)**
    - **procedure "tabletop" walk-through and review**
    - **operational readiness test rehearsal (nominal timeline)**
    - **2nd procedure "tabletop" review of revisions (if needed)**
    - **operational readiness test (with spacecraft simulator and injection of simulated spacecraft and ground system anomalies)**
  - **Contingency plans reviewed and exercised for each phase**
    - **plans exercised in operational readiness tests**
  - **Anomalies conceived and implemented by "gremlin" team without knowledge of flight team**

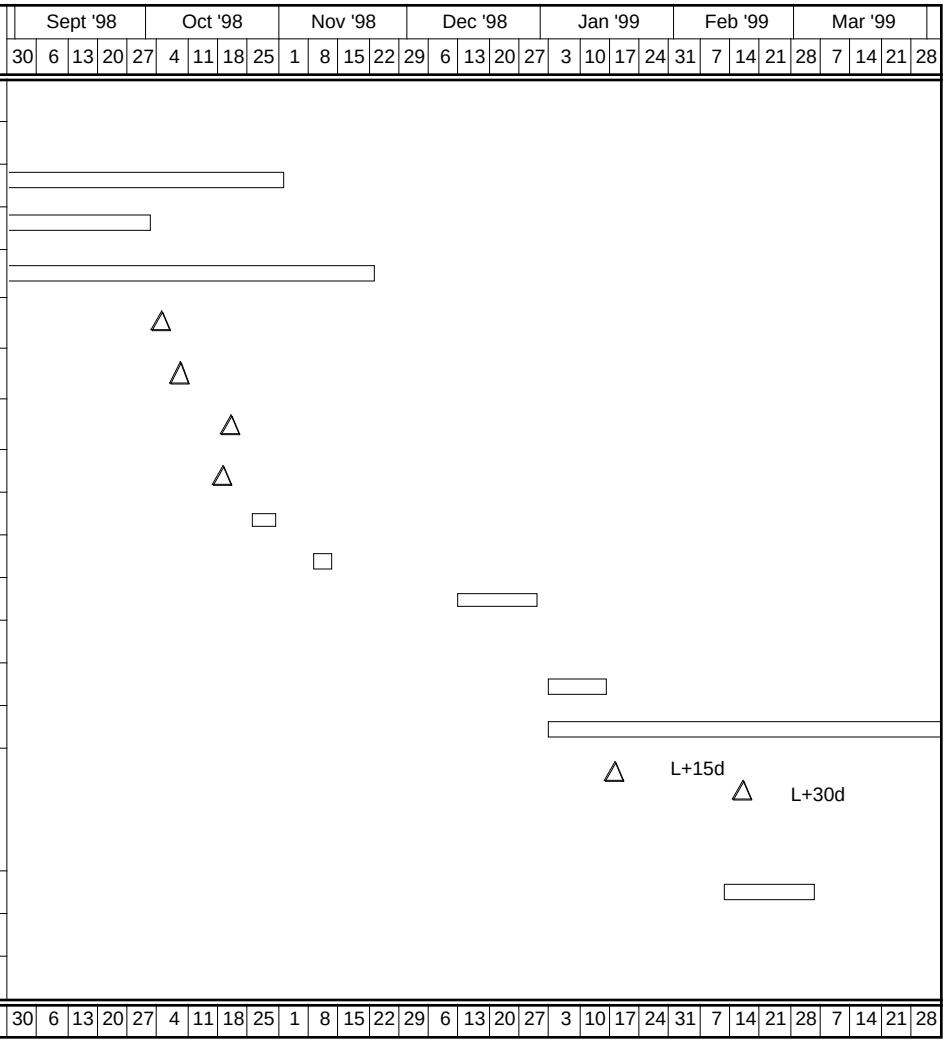
FLIGHT OPERATIONS SCHEDULE

Activity Name	Start Date	Finish Date
MCO Activities		
MCO Test & Training		
Orbiter MSTs	3/13/98	10/1/98
Launch Test & Training	7/31/98	11/23/98
Launch and Initial Acq (TableTop)	9/21/98	
Launch and Initial Acquisition ORT (Rehearsal)	9/25/98	
Launch and Initial Acq	10/5/98 11/17/98	
TCM (TableTop)	9/23/98	
TCM (Rehearsal)	9/28/98	10/9/98
TCM (Final ORT)	10/12/98	10/16/98
Earth-Moon MARCI Cal (TableTop)	11/2/98	
Earth-Moon MARCI Cal (Rehearsal)	11/5/98	11/6/98
Earth-Moon MARCI Cal (Final ORT)	11/19/98	11/21/98
Flight Sequence Development	11/19/98	12/10/98
MCO Flight Activities		
Oribter Launch Window	12/10/98	12/23/98
Orbiter Cruise Phase	12/10/98	10/2/99
TCM's	12/25/98 1/23/99 7/25/99 9/13/99	
Oribter MOI Window	9/23/99	10/4/99
Orbiter A/B Operations	9/28/99	12/4/99
Orbiter Transition to Mapping	12/1/99	12/2/99
Relay/Lander Support	12/3/99	3/1/00



FLIGHT OPERATIONS SCHEDULE (cont'd)

Activity Name	Start Date	Finish Date
MPL Activities		
MPL Test & Training		
Lander MSTs	3/13/98	11/1/98
TMOD MPL MSTA Campaign	7/1/98	10/1/98
Launch Test & Training	7/31/98	11/23/98
Launch and Initial Acq (TableTop)	10/5/98	
Launch and Initial Acquisition ORT (Rehearsal)	10/9/98	
Launch and Initial Acquisition w/recycle ORT (Rehearsal)	10/21/98	
TCM ORT (TableTop)	10/19/98	
TCM ORT (Rehearsal)	10/26/98	10/30/98
TCM ORT (Final ORT)	11/9/98	11/13/98
Flight Sequence Development	12/13/98	12/31/98
MPL Flight Activities		
Lander Launch Window	1/3/99	1/16/99
Lander Cruise Phase	1/3/99	12/5/99
TCMs	1/18/99 2/17/99 10/4/99 12/1/99 12/3/99	
Sci Checkout (L+ 40 days)	2/13/99	3/5/99
Sci Checkout (A - 90 days)	9/4/99	9/11/99
Lander Entry Window	12/3/99	12/15/99



OPEN ITEMS

- **MCO X-band Transmitter Operation**
  - **Spacecraft capable of continuous SSPA operation**
  - **May need to turn off during some periods to avoid corrupting tracking passes for other spacecraft (MPL, Stardust, Cassini)**
  - **Will evaluate trajectories of affected spacecraft to establish if periods of on/off cycling needed prior to MCO launch**
- **MPL X-band Transmitter Operation**
  - **Awaiting results of cruise thermal/vacuum test 2-7 Sep 98**
  - **Plan in place to obtain max. on/min off cycle specification and incorporate into ops plan by 5 Oct 98**
- **MCO In-flight UHF Radio Test**
  - **Desire test to verify UHF system to extent possible**
  - **Considering MCO downlink test during science checkout sequence at L+80 days with Stanford or Arecibo antennas**
  - **Will complete evaluation and finalize plan by launch**

SUMMARY

- **Plan in Place to Achieve Launch Readiness**
  - **Remaining tasks identified**
  - **Workforce and schedule adequate to complete tasks**
  - **Schedule margin held against plan**
- **Open Items**
  - **Need for MCO X-band transmitter cycling during cruise**
  - **MPL X-band transmitter max. on / min off cycle**
  - **MCO UHF radio test (downlink from orbiter)**
- **Work To Go (closure dates in MSOP integrated schedule)**
  - **Flight set of onboard blocks**
  - **MOS / flight system interface verification**
  - **Flight procedure development**
  - **Operational Readiness Test series**

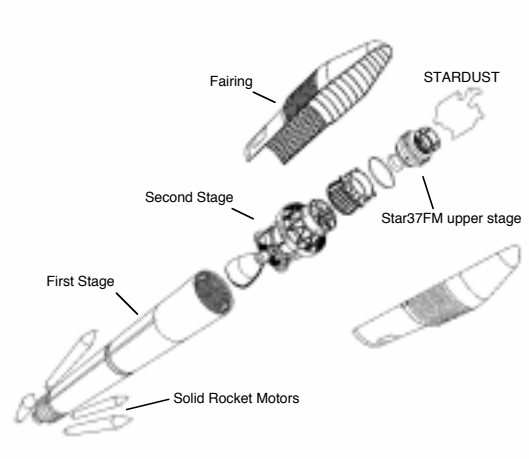
STARDUST FLIGHT OPERATIONS OVERVIEW
NASA Discovery Comet Sample Return Mission

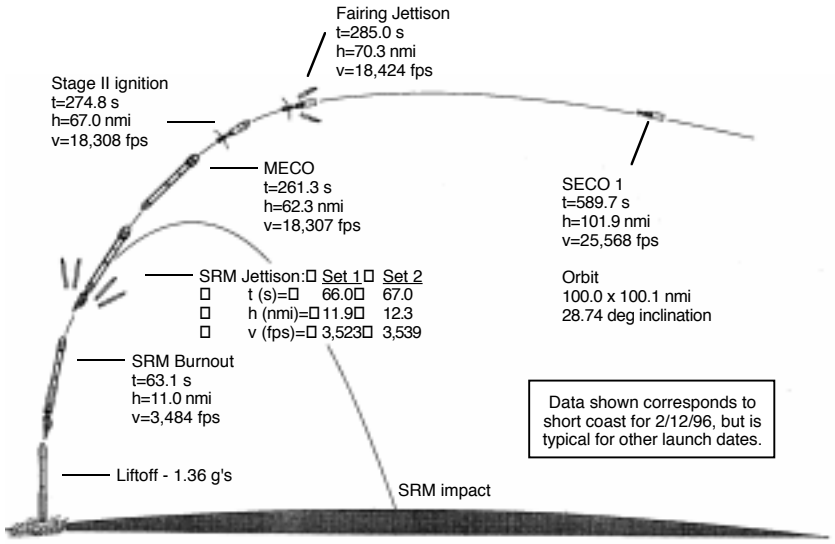
Thomas C. Duxbury
STARDUST Mission Manager
&
MGS MOLA Science Team Member

MISSION DESCRIPTION

7 YEAR MISSION LIFETIME

- **Launch: 06 Feb 1999 from 17A**
  - **Delta 7437**
  - **2 months after MS'98 Orbiter Launch from 17A**
  - **1 month after MS'98 Lander from 17B**
  - **Initial Acquisition over Canberra**

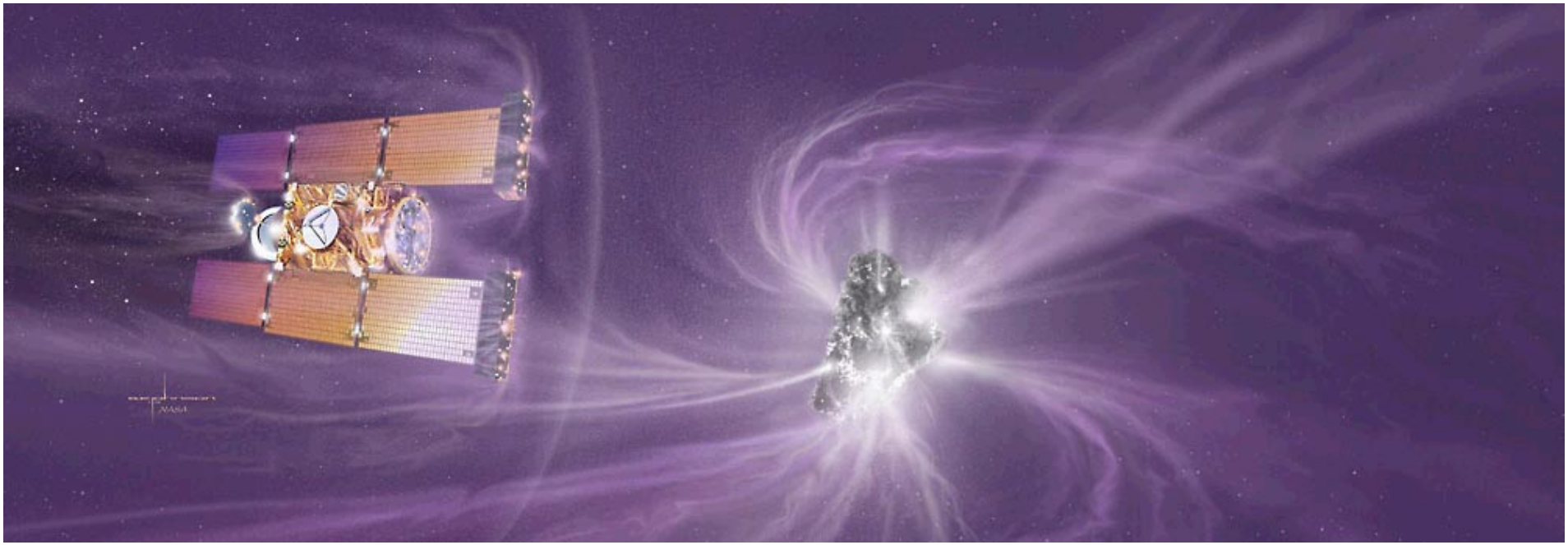




MISSION DESCRIPTION - CONT.

Earth Gravity Assist: 14 Jan 2001

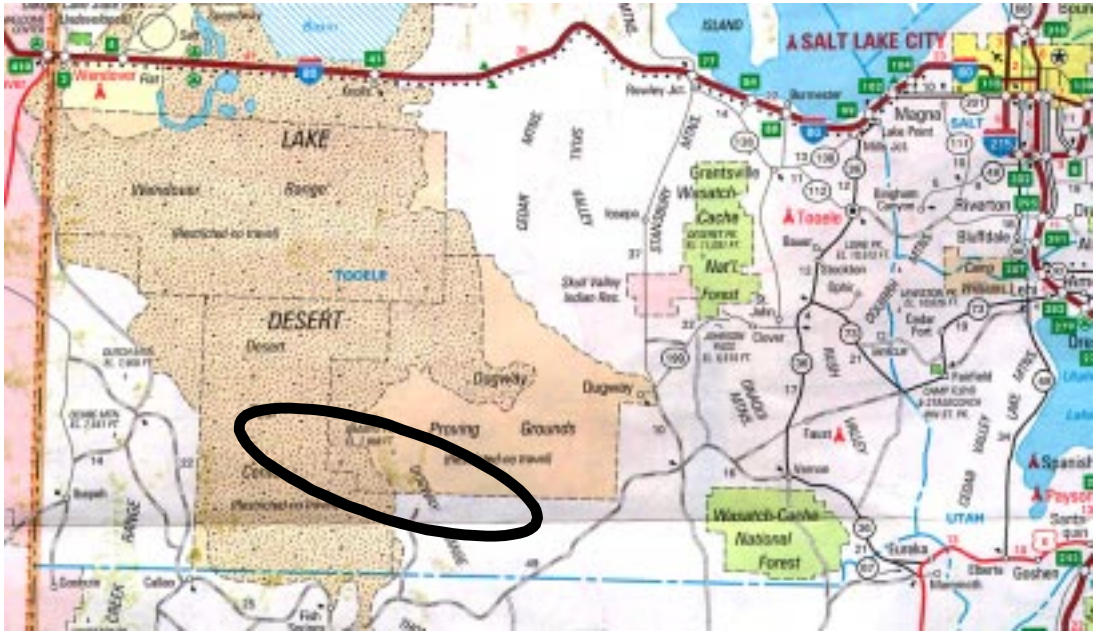
Wild 2 Flyby: 02 Jan 2004



Mars Surveyor Operations

MISSION DESCRIPTION - CONT.

Earth Return: 15 Jan 2006

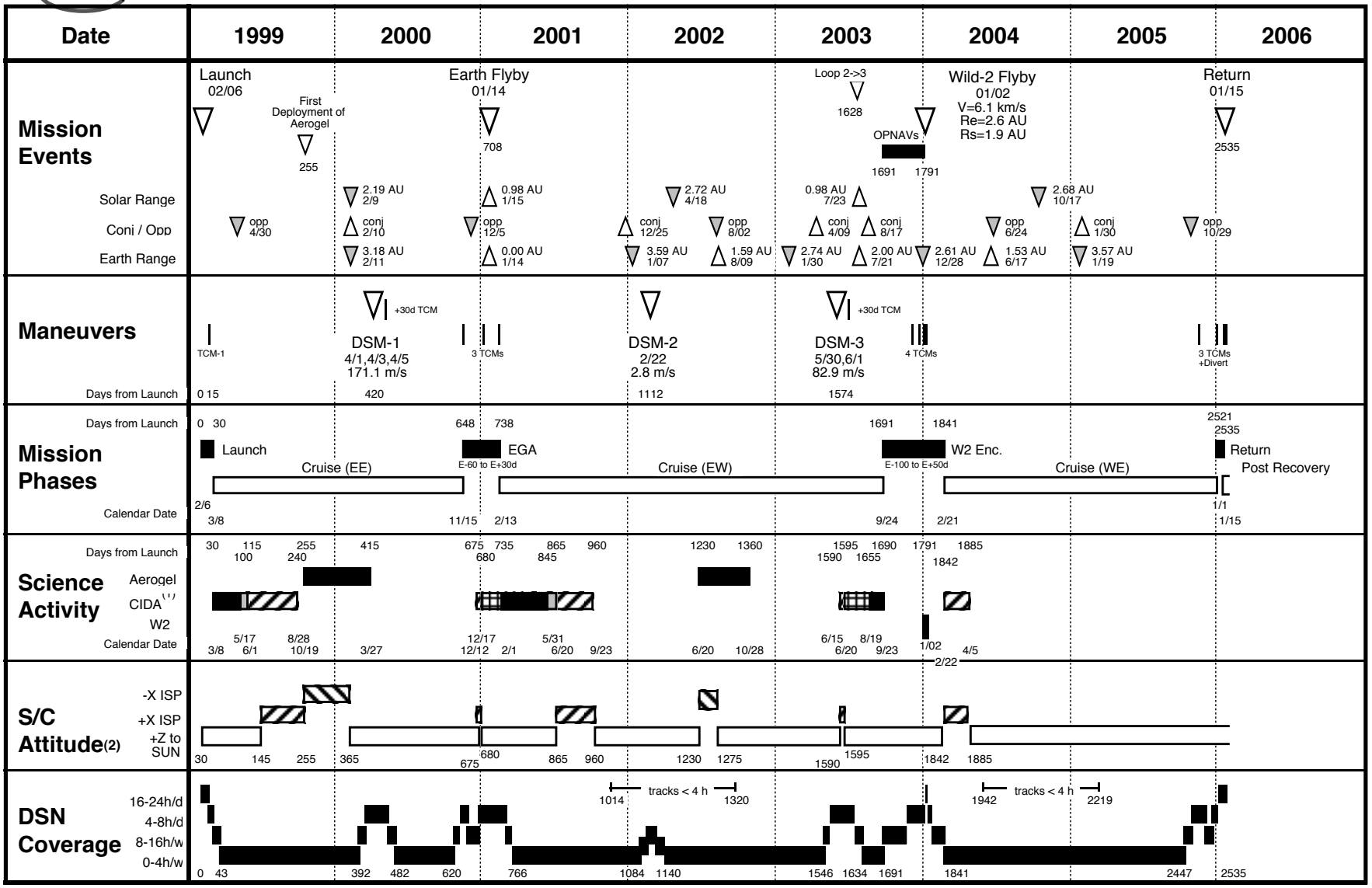


Utah Test & Training Range

Landing Ellipse
22.6 x 61.2 km² (3σ)

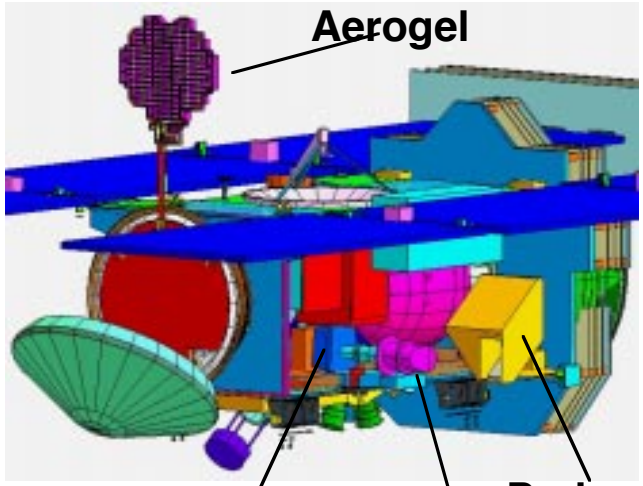
Mars Surveyor Operations

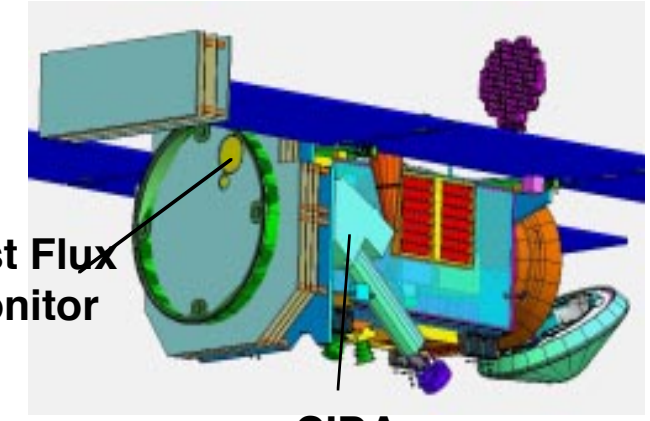
STARDUST MISSION TIMELINE



1. Solid+cross-filled bars indicate periods where the B=1 particle can be kept incoming along the spacecraft +x axis by changing the spacecraft attitude. Solid+gray bars indicate time where particle can be kept within the FOV without changing the spacecraft attitude. The slanted-line filled bars indicates periods of time the spacecraft attitude must be altered to keep the B=1 particle within the CIDA FOV.
2. Denotes primary attitude reference. Does not show regular communication periods or flyby science acquisition periods. -X ISP shows ISP capture off-Sun pointing. +X ISP shows possible off-Sun pointing for CIDA as per note 1.

STARDUST SPACECRAFT





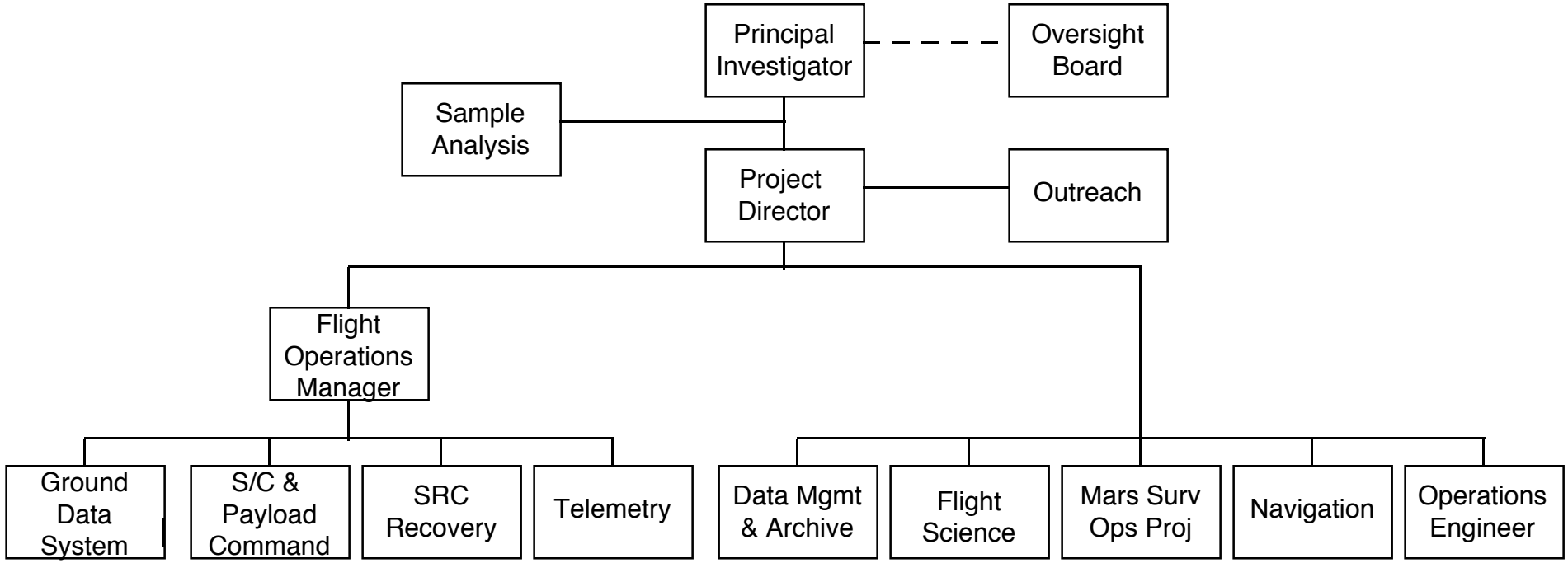
- 3 - Axis Stabilized (Sun Sensors and Star Camera)
- Fixed Antenna & Solar Panels
  - Antenna Points at Earth at Wild 2 Flyby
- Separable Sample Return Capsule
- Dust Collector (JPL Aerogel & LMA Structure / Mechanisms)
  - 2 Sided for Comet and Interstellar Dust Collection
- Max Planck Institute Cometary and InterPlanetary Dust Mass Spectrometer (Time of Flight)
- Univ of Chicago Dust Flux Counter
- JPL Nav Camera for Science Imaging
- JPL Radio Science
- LMA High Rate Attitude

Mars Surveyor Operations

STARDUST / MSOP Relationship

- **MSOP Providing GDS (Full Lifecycle w/ TMOD Support)**
- **STARDUST to Perform Operations**
  - **LMA to Perform S/C Monitor, Sequence Integration & Command**
  - **JPL performs Mission Management, DSN Scheduling**
- **STARDUST to Perform Data Management and Archive**
  - **JPL NAIF w/ ACT (SDB) like Clementine**
    - **All EDR and SPICE Kernel Production**
    - **I/F for Science Teams to STL, ATLO & Flight Data - No SOPC's**
- **STARDUST uses JPL TMOD MultiMission Nav Team**
  - **Radio Nav, Optical Nav & Comet Ephemerides**
  - **4 hrs tracking per week during 6 + years of cruise**
- **JPL Provides Optical Nav Related Flight Software**
  - **Pattern Matching, Windowing & Nucleus Tracking**

STARDUST FLIGHT ORGANIZATION



STARDUST Flight Operations, Command and Recovery Enterprise - FORCE

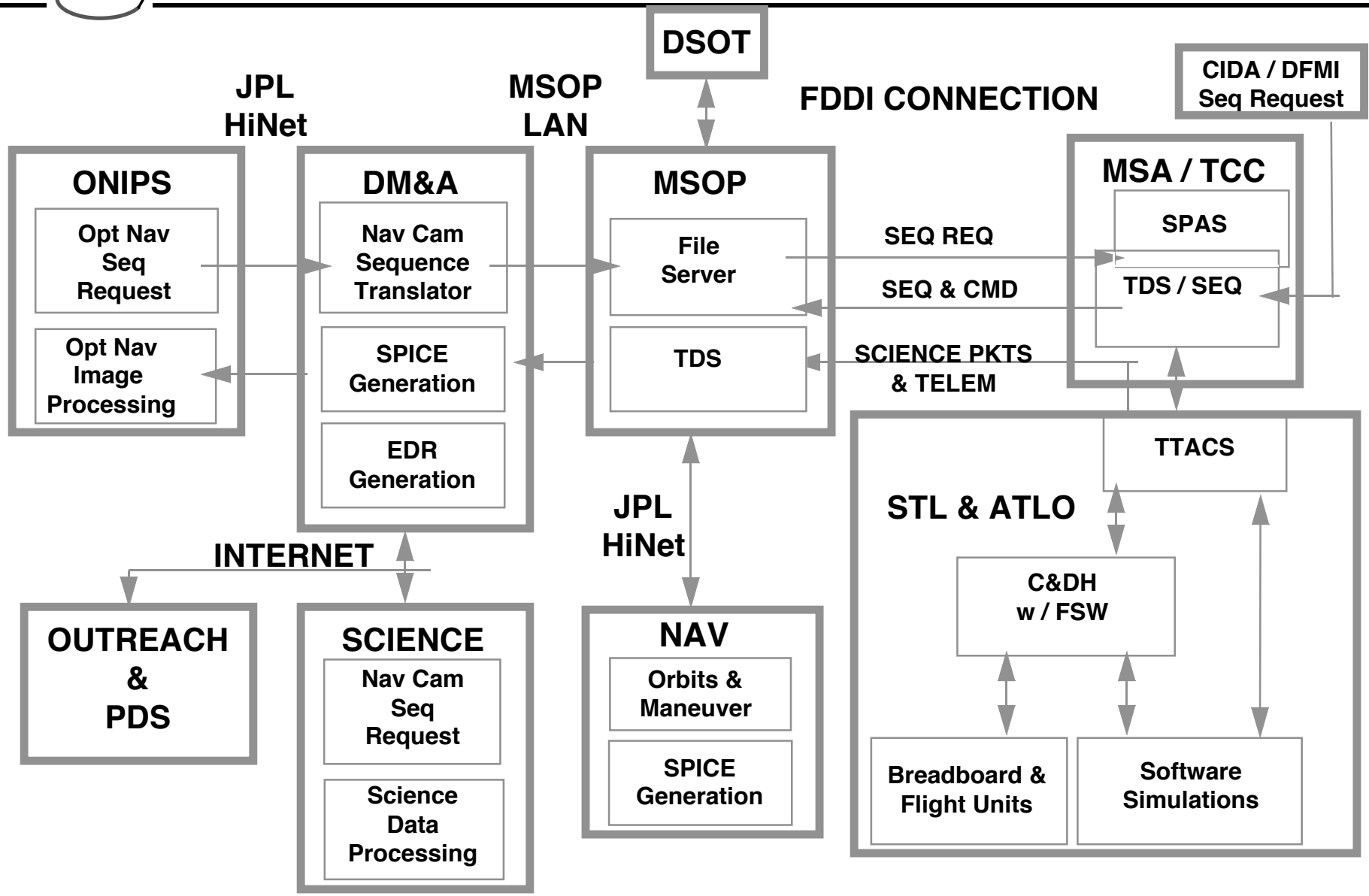
JPL Ops Room - 200 ft^2

STARDUST REQUIREMENTS ON MSOP

- **Provide GDS Lifecycle Management w/ TMOD Support**
  - **Requirements, Design, Implement, Test, Maintain, Change Control, Problem Definition and Resolution, Y2K Compliance, ISO 9001, CCSDS Standards, . . .**
- **Provide GDS Infrastructure**
  - **Computers, Data & Voice Connectivity, Security, Procedures, Training, . . .**
- **Provide Command Capability**
  - **SEQ S/W, ACT, ASP, . . .**
- **Provide Health, Safety & Performance Monitor Capability**
  - **SPAS, TPAP, DMD, . . .**
- **Provide Telemetry Capability**
  - **GIF, TIS, TDS, Priority Table, . . .**
- **Provide Interchange Capability**
  - **FIS**
- **Provide Emergency Command Center**

Mars Surveyor Operations

STARDUST DATA FLOW



Mars Surveyor Operations

MECHANISMS TO DEFINE REQUIREMENTS

- STARDUST - MSOP MOU, Jan 1997
- Mission Plan 3.0, Jul 1998
- Navigation Plan 3.0, Aug 1998
- Command Dictionary 3.4.0, Jul 1998
- Block Dictionary Final, Aug 1998
- Telemetry Dictionary 3.4.1, Aug 1998
- Flight Rules & Constraints Preliminary, Aug 1998
- VOCA Requirements - May 1998
- MOS Plan: Requirements (Feb 1998) , Organization (Mar 1998) , Operational Interfaces (Evolving), Test & Training (Evolving), Procedures (Evolving)
- SPAS Requirements Preliminary, May 1998
- Proj Req / Tech Support Agreement
- ATLO Schedules, Plans & Procedures
- MSOP Weekly Design Team Meeting

Mars Surveyor Operations

MISSION OPERATIONS SUPPORT

- **Cruise Mode - 6+ Years of 7 Year Mission**
  - **4 hours Comm per Week**
  - **Prime Shift, 5 Days per Week**
  - **Weekly Meeting w/ Mgmt, SCI, S/C, Nav, DM&A, . . .**
    - **Review Previous Downlink**
    - **Review Next Command Load**
    - **Review Compliance to Mission Plan**
    - **Review Change requests**
- **Off Prime Support Required**
  - **Launch: Feb 1999 - 2 weeks**
  - **Earth Gravity Assist: Jan 2001 - 2 weeks**
  - **Wild 2 Flyby: Jan 2004 - 2 weeks**
  - **Earth Return: Jan 2006 - 2 weeks**

Mars Surveyor Operations

MSOP IMPLEMENTATION APPROACH

- **Augment / Adapt Existing and Evolving MGS & MS'98 GDS**
  - **Starting with Existing System - put STARDUST 6 Months Ahead of Schedule**
  - **STARDUST Launches 2 months after MS'98 Orbiter and 1 month after MS'98 Lander**
  - **STARDUST Shares 70+ % of MS'98 Orbiter Flight Software**
  - **Same Facilities (JPL, LMA, KSC)**
  - **Same Data & Voice Connectivity Requirements**
  - **Use LMA Mission Support Area and Personnel**
- **MSOP GDS Deliveries have kept STARDUST MOS many months ahead of Flight System Development**
- **Allowed STARDUST to**
  - **Test Early and Often**
  - **Test as will be Flown**
  - **Test All Mission Phases, Sequences, Block Commands, Fault Modes, . . .**
- **MSOP Represents GDS at PDR, CDR, ATLO RR, LRR, . . .**

Mars Surveyor Operations

STARDUST STATUS

- **All Plans, Requirements, Rules, Constraints, . . . in Place**
- **Launch Version C4.3 (Update II) of GDS in Place**
  - **FORCE is Operational**
  - **TPAP in Progress**
- **Launch Version C5.0 Scheduled 01 Nov 1998**
  - **2 Weeks Before Flight Unit Arrives**
  - **Will Provide all Data & Voice Links**
- **STARDUST will have ORR & LRR prior to Launch with MSOP Participation**

VERY HIGH CONFIDENCE IN LAUNCH READINESS

Mission Support and Development

Ben Jai

Nino Lopez

Peter Theisinger

Mission Support and Development

Agenda

Ground Data System Readiness

- **Network Architecture**
- **Special Requirements**
- **Capability Improvements Since MGS Launch**
- **Downlink / Uplink Data Flow**
- **Launch, Aerobraking Phase II and Cruise Support**
- **Development and Test Status**

Launch and Cruise Operations Readiness

- **MSP'98 Ops Teams Overview**
- **Processes / Procedures / OIA's**
- **MOS Compatibility Tests**
- **Test and Training**

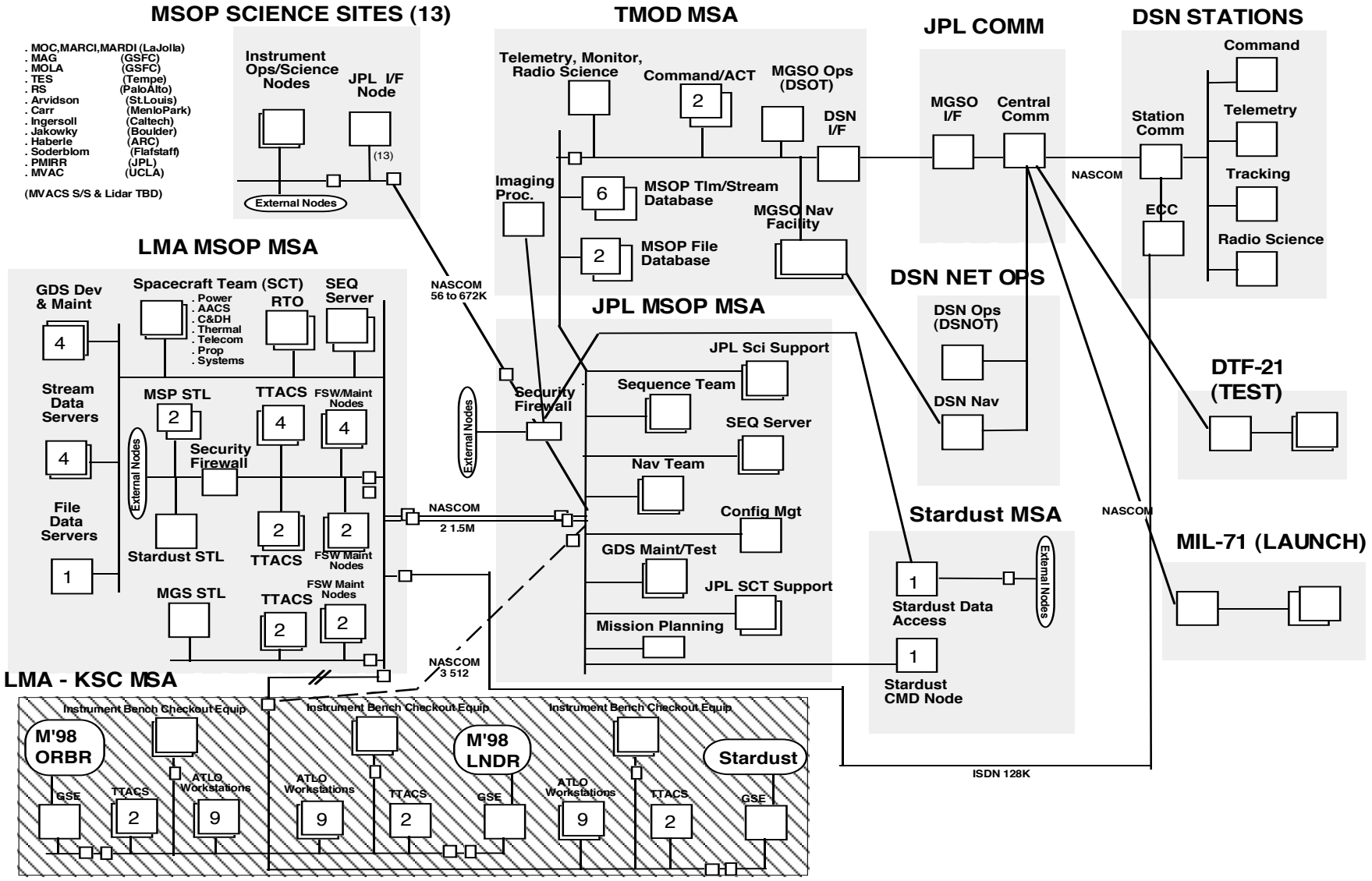
Open Items / Concerns

Readiness Statement

Ben Jai

Mars Surveyor Operations

NETWORK ARCHITECTURE



Mars Surveyor Operations

SPECIAL REQUIREMENTS

- **GENERAL**
  - **EMERGENCY CONTROL CENTER**
  - **MULTIMISSION PERFORMANCE**
  - **RELIABILITY**
- **MGS AEROBRAKING PHASE II**
  - **IMPROVEMENTS TO NAVIGATION PREDICTION AND RECONSTRUCTION**
- **M98 ORBITER AND LANDER**
  - **FILE LOAD**
  - **PACKET TELEMETRY WITH DOWNLINK PRIORITY TABLE**
  - **ADVANCED PLANNING FOR LANDER SCIENCE**
  - **EDL TARGET AND EPHEMERIS COMPUTATION**
- **STARDUST**
  - **FILE LOAD**
  - **PACKET TELEMETRY WITH DOWNLINK PRIORITY TABLE**

Mars Surveyor Operations

CAPABILITY IMPROVEMENTS SINCE MGS LAUNCH

Capabilities Since MGS Launch	MGS A/B P2		M98 Orbiter		M98 Lander		Stardust	
	DEV	TEST	DEV	TEST	DEV	TEST	DEV	TEST
Uplink								
Command Tracking (ACT Performance)	√	√	√	In process	√	In process	√	In process
Automated Sequence/Command Generation (triggered by email and other improvements)	√	√	√	In process	√	In process	In process	In process
ACE Utilities	√	√	In process	In process	In process	In process	In process	In process
Sequence Adaptation	√	√	In process	In process	In process	In process	In process	In process
Multimission Commanding Support	√	√	N/A	N/A	N/A	N/A	N/A	N/A
File loading and tracking	N/A	N/A	In process	Planned	In process	Planned	In process	Planned
Lander Command Relay via Orbiter*	N/A	N/A	√	√	N/A	N/A	N/A	N/A
Downlink								
Automatic Alarm Notification	√	√	In process	In process	In process	In process	In process	In process
Remote Telemetry Access	√	√	In process	In process	In process	In process	In process	In process
Reliable Telemetry Delivery(RNS, CDR TDS)	√	√	√	√	√	√	√	√
Telemetry Processing System Adaptation	N/A	N/A	√	In process	√	In process	√	In process
SCT NOCC Display	√	√	√	√	√	√	√	√
Lander TLM Relay via M98 Orbiter*	N/A	N/A	√	√	N/A	N/A	N/A	N/A

*: Not Launch/cruise capabilities

Mars Surveyor Operations

CAPABILITY IMPROVEMENTS SINCE MGS LAUNCH

Capabilities Since MGS Launch	MGS A/B P2		M98 Orbiter		M98 Lander		Stardust	
	DEV	TEST	DEV	TEST	DEV	TEST	DEV	TEST
Navigation/Tracking								
EDL Targeting and Ephemeris Gen*	N/A	N/A	N/A	N/A	√	In process	N/A	N/A
Automatic Radio Matric Conditioning	√	√	√	√	√	√	N/A	N/A
Small Forces File Generaton	N/A	N/A	N/A	N/A	√	In process	N/A	N/A
Atmospheric Entry*	N/A	N/A	N/A	N/A	√	In process	N/A	N/A
Aerobraking prediction & reconstruction improvements	√	√	N/A	N/A	N/A	N/A	N/A	N/A
SCT								
SPAS Upgrade	√	√	√	In process	√	In process	√	In process
Telecom Performance Analysis	In process	In process	Open		Open		Open	
ABGEN Upgrade(MGS AB SEQ generation and memory mgmt)	√	√	N/A	N/A	N/A	N/A	N/A	N/A
Science*								
APGEN with Power Model	N/A	N/A	N/A	N/A	In process	In process	N/A	N/A
MIPS	N/A	N/A	N/A	N/A	In process	In process	N/A	N/A

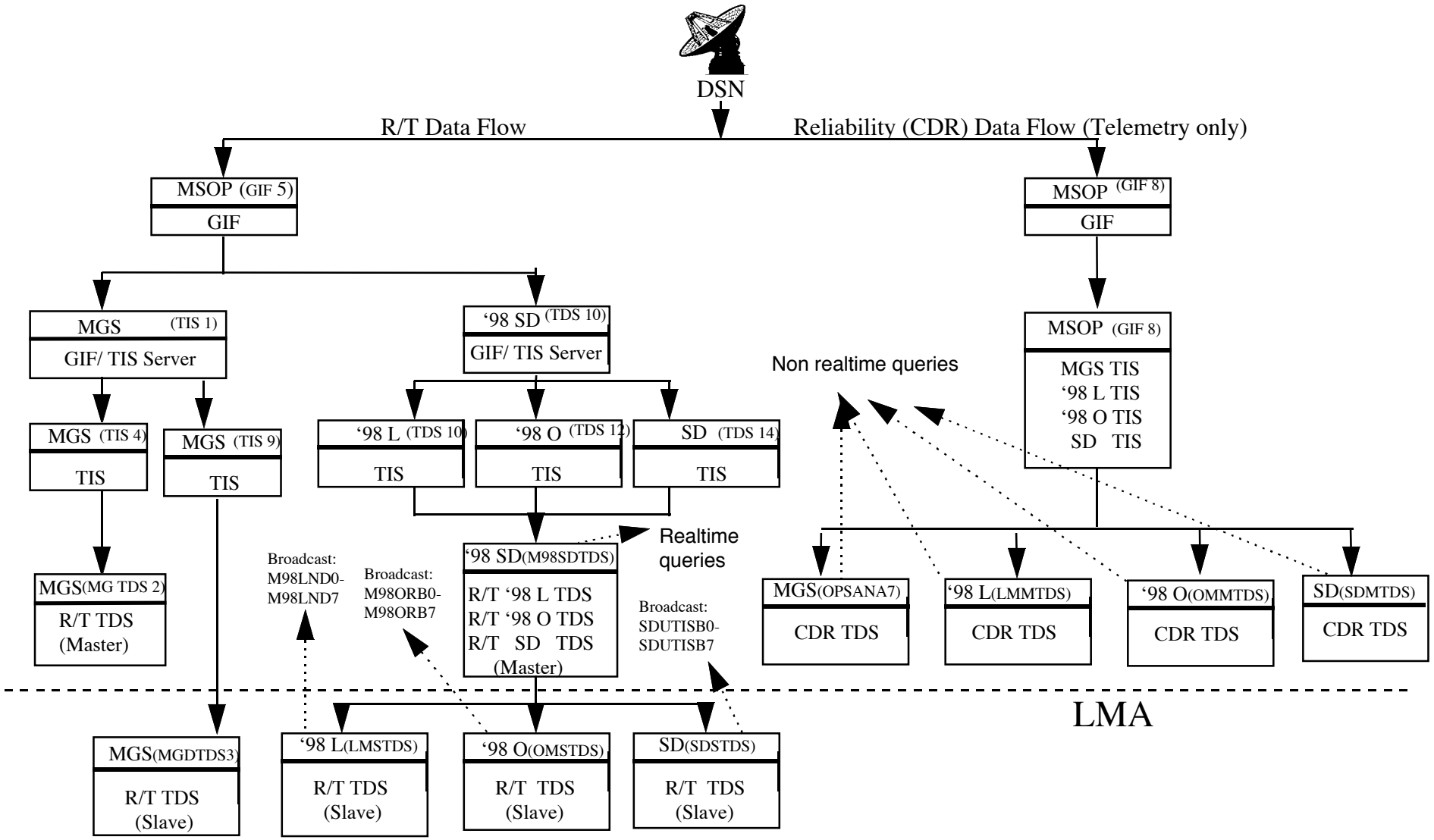
*: Not Launch/cruise capabilities

Mars Surveyor Operations

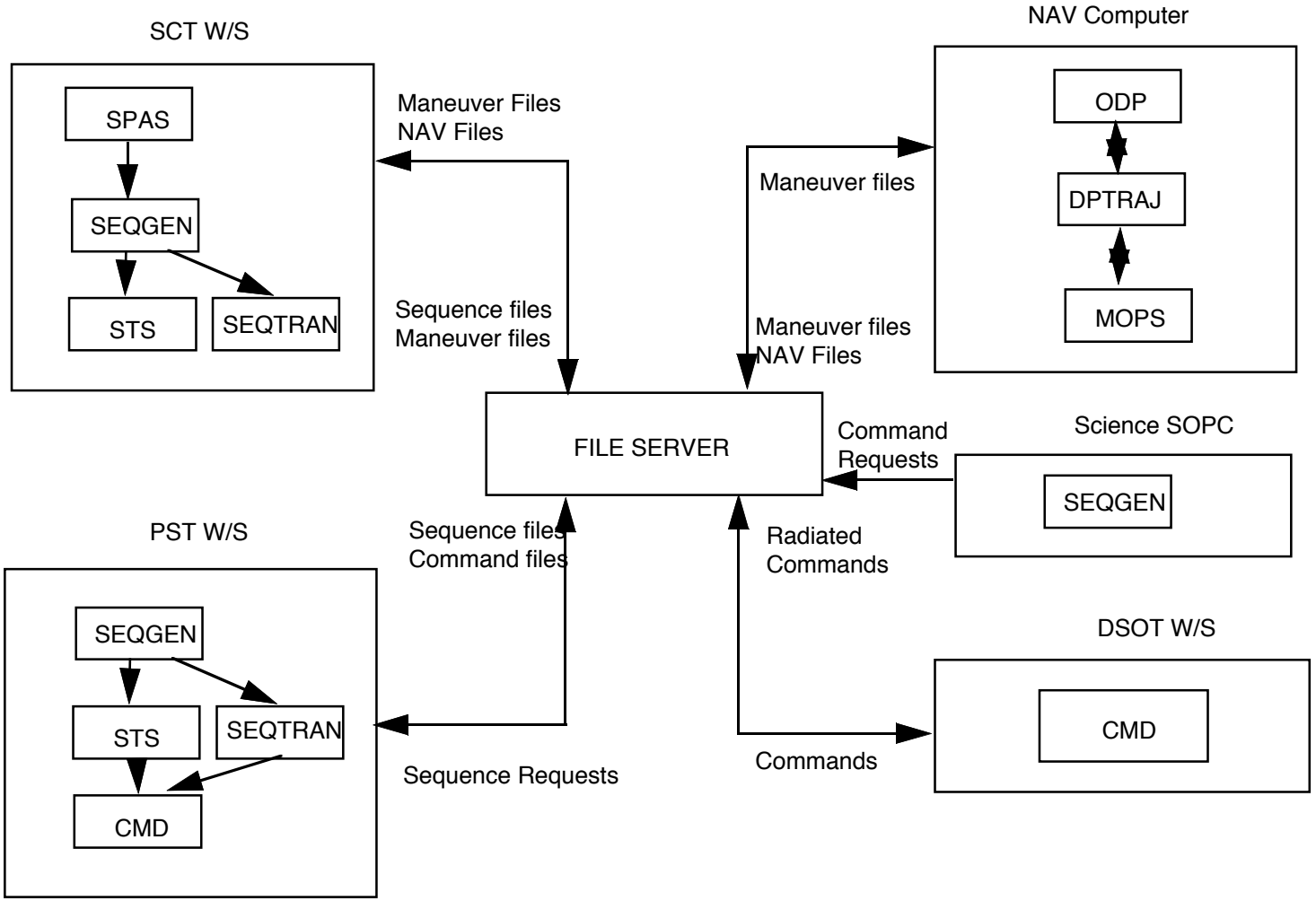
CAPABILITY IMPROVEMENTS SINCE MGS LAUNCH

Capabilities Since MGS Launch	MGS A/B P2		M98 Orbiter		M98 Lander		Stardust	
	DEV	TEST	DEV	TEST	DEV	TEST	DEV	TEST
Infrastructure								
File Notification	√	√	√	√	√	√	√	√
File Release	√	√	√	√	√	√	√	√
File Interchange	√	√	√	√	√	√	√	√
Solaris Environment	√	√	√	√	√	√	√	√
SPICE-Kernel	√	√	√	√	√	√	N/A	
Emergency Control Center	In process		In process		In process		In process	
Hardware & Network								
SOPC Upgrade and Installation	√	√	√	√	√	√	N/A	
M98 SOPC Network	N/A	N/A	√	√	√	√	N/A	N/A
SCT Hardware Upgrade	√	√	√	√	√	√	√	√
PST Hardware Upgrade	√	√	√	√	√	√	N/A	N/A
NAV Hardware Upgrade	√	√	√	√	√	√	N/A	N/A
KSC Configuration	N/A	N/A	Planned		Planned		Planned	
LMA Security Firewall	√	√	√	√	√	√	√	√
JPL LMA Network Enhancements (3 T1)	√	√	√	√	√	√	√	√

DOWNLINK DATAFLOW



UPLINK DATA FLOW



Mars Surveyor Operations

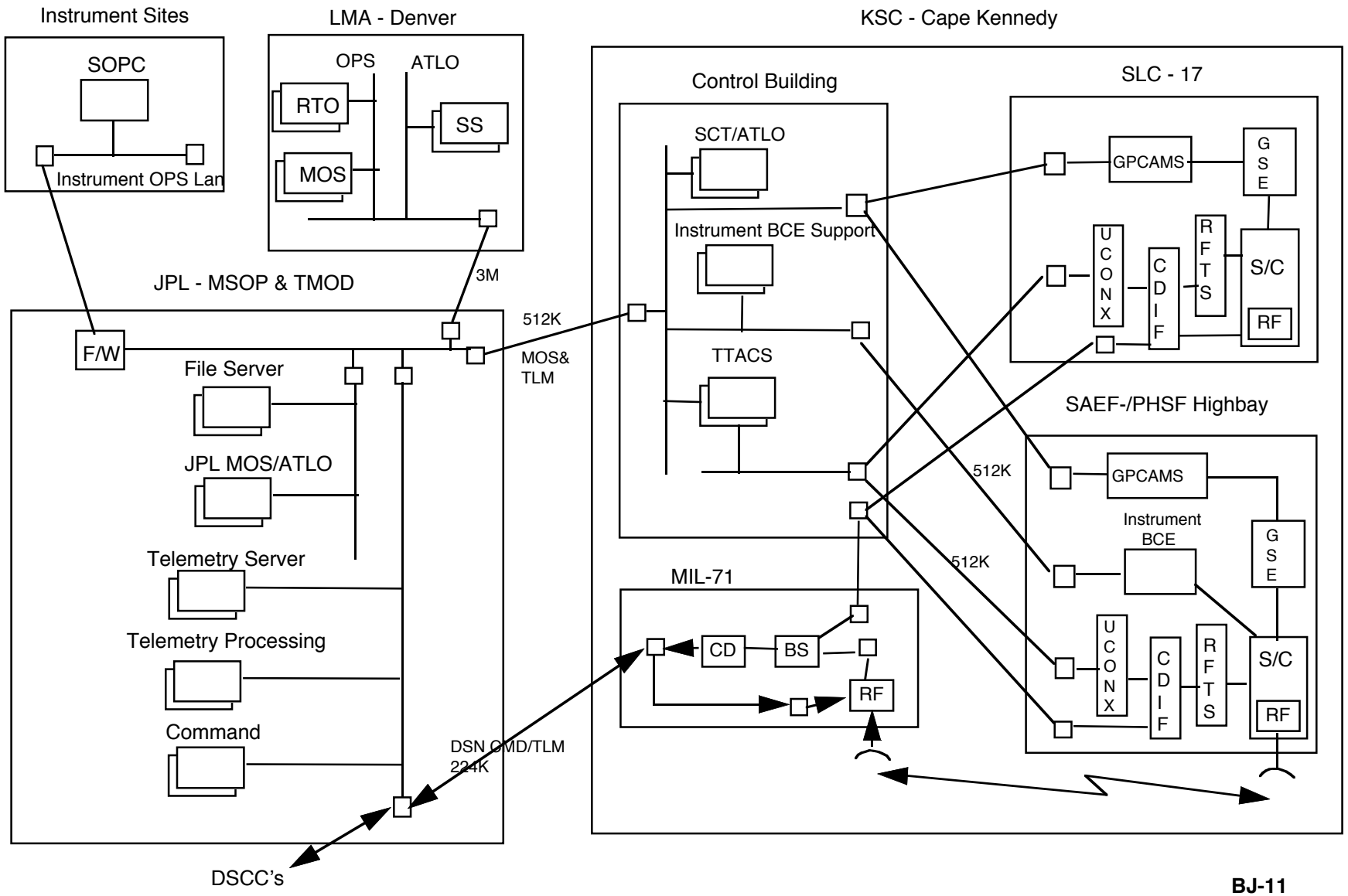
LAUNCH OPERATIONS SUPPORT

- **GENERAL**
  - **SCT OPERATIONS AT LMA**
  - **REALTIME OPERATIONS (COMMAND)AT LMA**
    - **JPL COMMAND BACKUP SUPPORT**
  - **ATLO SUPPORT TEAM AT KSC AND LMA**
  - **INSTRUMENT OPERATIONS AT KSC AND INSTRUMENT OPS SITES**
  - **NAVIGATION OPERATIONS AT JPL**
  - **SEQUENCE OPERATIONS AT JPL FOR MARS 98 AND AT LMA FOR STARDUST**
  - **TMOD OPERATIONS AT JPL, MIL-71 AND DSCC's**
- **SAEF-2(M98)/PHSF(STARDUST) OPERATIONS**
  - **S/C AND GSE IN HIGH-BAY**
  - **ATLO OPS IN SAEF-2/PHSF CONTROL BUILDING (INCLUDING INSTRUMENT BCE'S)**
  - **STANDALONE TTACS COMMAND/TELEMETRY OPERATIONS AT SAEF-2/PHSF CONTROL BUILDING**
  - **MOS DATA INTERFACES TO JPL AND LMA VIA KSC WAN (INCLUDING CMD AND TLM)**
  - **TELEMETRY VIA HARDLINE TO MIL 71**
  - **COMMAND TELEMETRY VIA RF/MIL-71**

LAUNCH OPERATIONS SUPPORT - cont'd

- **S/C LAUNCH COMPLEX - 17 OPERATIONS**
  - **S/C ON LAUNCH PAD**
  - **GSE IN BLOCKHOUSE**
  - **ATLO OPERATIONS IN SAEF-2/PHSF CONTROL BUILDING**
  - **INSTRUMENT BCE'S IN SAEF-2/PHSF CONTROL BUILDING**
  - **COMMAND AND TELEMETRY VIA TTACS AND UMBILICAL**
- **ASCENT & INITIAL ACQUISITION**
  - **S-BAND ACQUISITION AND X BAND ACQUISITION AID VIA DSS 46**
  - **X-BAND ACQUISITION VIA DSS 45**
  - **ASCENT STATE VECTORS FROM KSC AND GSFC TO DSN AND PROJECT NAV**

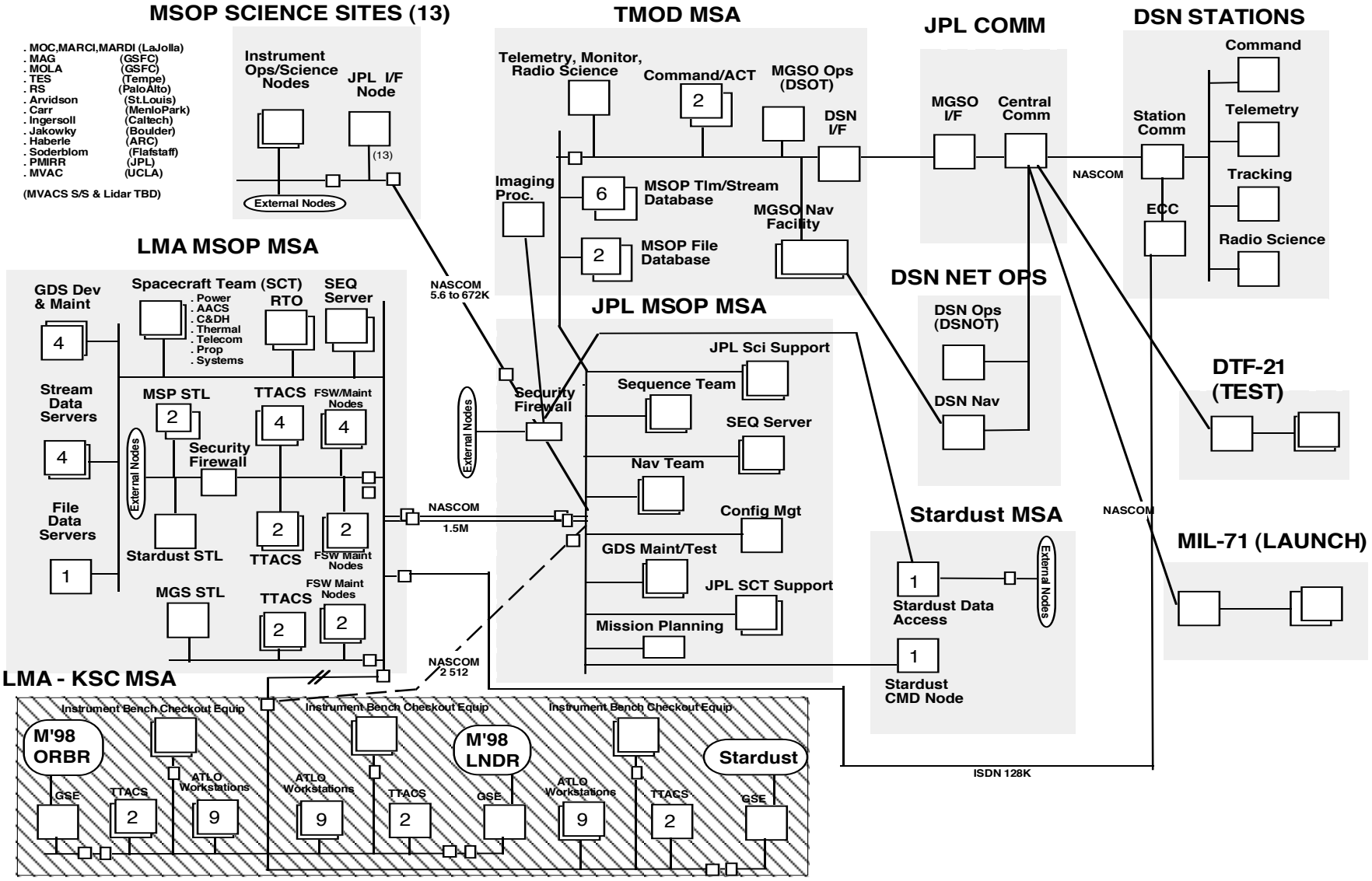
NETWORK ARCHITECTURE - LAUNCH



AEROBRAKING PHASE II AND CRUISE OPS SUPPORT

- **GENERAL ACTIVITIES**
  - **SCT OPERATIONS AT LMA**
  - **STL OPERATIONS AT LMA**
  - **REALTIME OPERATIONS AT LMA**
    - **BACKUP ACE AT JPL**
    - **MMCT SUPPORT FOR NIPC AT JPL**
  - **SCIENCE INSTRUMENT OPERATIONS AT INSTRUMENT OPS SITES**
    - **MGS - MSSS, ASU, GSFC(2), STANFORD**
    - **M98 - UCLA, MSSS, JPL**
    - **SD - JPL**
  - **NAVIGATION AT JPL**
  - **SEQUENCE AT JPL FOR MGS AND M98, AT LMA FOR SD**
  - **TMOD OPERATIONS AT JPL AND DSCC'S**

NETWORK ARCHITECTURE - A/B PHASE II & CRUISE



Mars Surveyor Operations

DEVELOPMENT AND TEST STATUS

- **COMMAND TRACKING**
  - **DEVELOPMENT, AND GDS TESTING COMPLETED**
  - **WILL BE OPERATIONALLY TESTED IN ORT**
- **ACE UTILITIES**
  - **MULTIMISSION UTILITIES DEVELOPED, TESTED**
  - **MISSION SPECIFIC UTILITIES TO BE DEVELOPED BY 10/15/98**
- **AUTOMATED SEQUENCE PROCESS**
  - **M98 PROCESSES DEFINED, DEVELOPED, AND GDS TESTED**
  - **WILL BE OPERATIONALLY TESTED IN ORT**
  - **SD PROCESS NOT COMPLETELY DEFINED, WORKING WITH STARDUST OPS PERSONNEL TO DEFINE THE PROCESS**
    - **TO BE COMPLETED BY 10/15/98**

DEVELOPMENT AND TEST STATUS (CONT'D)

- **SEQUENCE ADAPTATION**
  - **CONCURRENT DEVELOPMENT WITH LMA FLIGHT SYSTEM**
  - **FLIGHT SYSTEM DEVELOPMENT (BLOCK AND FLIGHT RULES)NOT FINALIZED**
  - **PLAN TO FINALIZE DEVELOPEMENT**
    - **9/15/98 FOR ORBITER**
    - **10/15/98 FOR LANDER**
    - **11/15/98 FOR STARDUST**
- **S/C FILE LOADING AND TRACKING**
  - **PHASE 1 DEVELOPMENT TO BE COMPLETED BY 9/1/98**
    - **PHASE 1 CONTAINS ALL THE BASIC FUNCTIONAL REQUIREMENTS**
  - **END TO END TEST TO BE COMPLETED IN CONJUNCTION WITH MST & SPT**
  - **PHASE 2 DEVELOPMENT TO BE COMPLETED BY 3/1/98**
    - **PHASE 2 CONTAINS IMPROVEMENTS BASED ON THE ORT, ACTUAL FLIGHT OPS AND ADDITIONAL AUTOMATION**

DEVELOPMENT AND TEST STATUS (CONT'D)

- **TELEMETRY ADAPTATION**
  - **GROUND SOFTWARE DEVELOPED AND GDS TESTED**
  - **IDENTIFIED DATA LOSS PROBLEMS TO THE DEVELOPMENT PROJECTS**
    - **PACKET GAPS WHEN FRAME IN SYNC**
    - **EXTRA BIT FRAMES**
- **SMALL FORCES FILE GENERATION**
  - **GROUND SOFTWARE DEVELOPED AND PARTIALLY GDS TESTED**
    - **OFFICIAL SPAS DELIVERY - 9/1/98**
    - **SMALL FORCES FILE PREDICTOR DELIVERY - 9/11/98**
  - **WILL BE OPERATIONALLY TESTED IN ORT**
- **TELECOM PERFORMANCE**
  - **MGS VERSION HAS BEEN CONVERTED FROM TPAP TO MSAS**
  - **SCT IS EVALUATING THE RESULTS TO BE COMPLETED BY 10/1/98**
  - **M98 AND STARDUST VERSION ARE UNDER NEGOTIATION**
- **KSC CONFIGURATION**
  - **START BUILDING KSC CONFIGURATION FROM SEPTEMBER 8, 1998**

DEVELOPMENT AND TEST STATUS (CONT'D)

- **EMERGENCY CONTROL CENTER**
  - **WORKSTATION CONFIGURATION TO BE COMPLETED BY THE END OF AUGUST 1998**
  - **NETWORK TO BE COMPLETED BY 11/1/98**
  - **END TO END TEST TO BE CONDUCTED BY 11/15/98**

Mars Surveyor Operations

PERFORMANCE FOR MULTIMISSION SUPPORT

- **EXPANSION AND UPGRADE ON ALL FLIGHT OPS WORKSTATIONS TO HANDLE INCREASED COMPUTATION NEEDS**
- **MULTIPLE TELEMETRY PROCESSING AND DELIVERY STRING TO SUPPORT MULTIPLE SPACECRAFTS**
- **CDR AND RNS TO IMPROVE DATA QUALITY**
- **INCREASED BANDWIDTH BETWEEN JPL AND LMA FOR MULTIMISSION SUPPORT**
- **VOCA EXPANSION TO ALLOW MULTIPLE PROJECTS' TRAFFIC**

Mars Surveyor Operations

RELIABILITY FOR MULTIMISSION SUPPORT

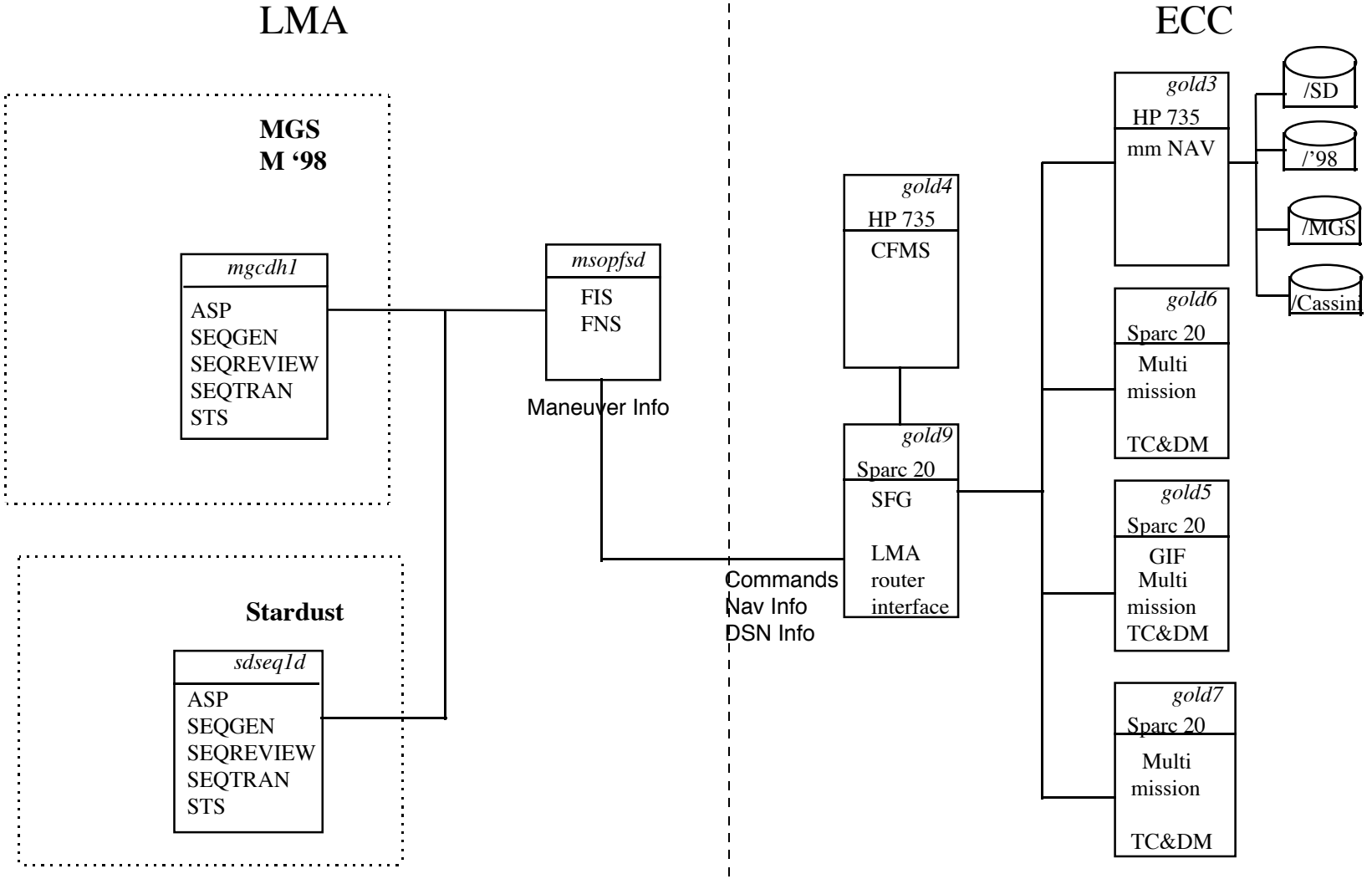
- **JPL-LMA CIRCUIT REDUNDANCY**
  - FULLY REDUNDANT NETWORK COMPONENTS AND CIRCUITS
  - REMOTE MONITORING & SWITCHING CAPABILITY @LMA
  - OPERATIONAL WORKAROUND PROCEDURES IDENTIFIED FOR A/B
- **FACILITIES POWER AT LMA**
  - DENVER MSA ON UPS POWER (20 MIN)
  - BACKUP GENERATOR POWER UNDER CONSIDERATION
  - TCC & STL AREAS NOT ON UPS
- **NAV COMPUTER REDUNDANCY**
  - REDUNDANT COMPUTERS AND CONNECTIVITY PROVIDED
- **RTO COMMAND REDUNDANCY**
  - REDUNDANT RTO COMMANDING PROVIDED @ JPL

Mars Surveyor Operations

RELIABILITY FOR MULTIMISSION SUPPORT(CONT'D)

- **SEQ ASP REDUNDANCY**
  - MULTIPLE ASP SERVERS TO PROVIDE REDUNDANCY
- **FILE SERVER REDUNDANCY**
  - MULTIPLE FILE SERVERS AT JPL AND BACKUP AT LMA
- **SCT ENVIRONMENT REDUNDANCY**
  - DUPLICATE SERVER LOCATED AT JPL WITH SPAS, ABGEN AND OTHER UTILITIES
- **JPL-KSC I/F**
  - REDUNDANT CIRCUITS PROVIDED (MCO, MPL, STARDUST)
  - COULD LAUNCH IN "KSC STANDALONE" MODE IF NECESSARY
- **KSC POWER**
  - UPS POWER PROVIDED FOR CRITICAL COMPONENTS
- **JPL MSOP GDS MAJOR OUTAGE**
  - EMERGENCY CONTROL CENTER IMPLEMENTED AT GOLDSTONE
  - CONNECTIVITY BETWEEN ECC & TRACKING STATIONS
  - CONNECTIVITY BETWEEN ECC & LMA

EMERGENCY CONTROL CENTER



Mars Surveyor Operations

EMERGENCY CONTROL CENTER

- ECC TO BE USED ONLY DURING EMERGENCY SITUATIONS
- MSOP JPL FUNCTIONS REDISTRIBUTED
  - SEQUENCE/COMMAND GENERATION
    - INSTALL AND CONFIGURE SEQUENCE WORKSTATION
      - MGCDH1 FOR MGS and Mars '98
      - SDSEQ1D FOR STARDUST
    - COMMAND INTERFACE BETWEEN LMA ACE AND ECC COMMAND CENTRAL
  - TELEMETRY DATA FLOW
    - TELEMETRY PROCESSING FACILITY LOCATED AT ECC
    - DATA TRANSFERED TO LMA TDS FOR SYSTEMS/SUBSYSTEMS TO USE
  - NAVIGATION PROCESSING
    - NAV H/W & S/W LOCATED AT ECC
    - TRACKING DATA TRANSFERED FROM DSCC'S
  - 128K DEDICATED ISDN LINE BETWEEN LMA AND ECC
- ECC AVAILABILITY
  - FACILITY AVAILABLE WITHIN 24 HOURS DURING SPECIFIED PERIOD, AND 72 HOURS DURING NON SPECIFIED PERIOD
  - VOICE T1 LINE BE CONVERTED TO DATA LINE WITHIN 72 HOURS

MSP'98
LAUNCH AND CRUISE OPERATIONS READINESS

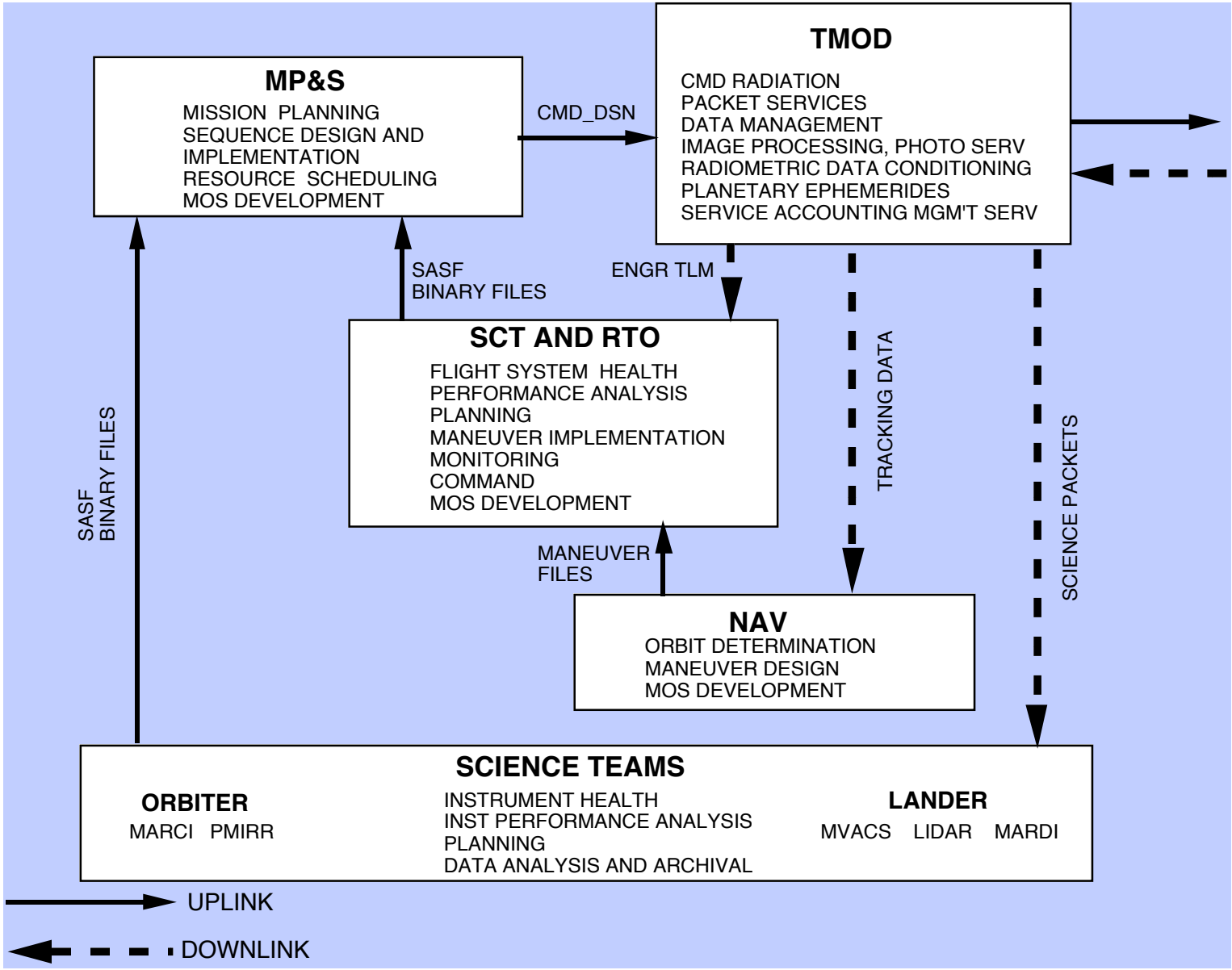
NINO LOPEZ

Mars Surveyor Operations

AGENDA

- MSP'98 OPS TEAMS OVERVIEW
- PROCESSES
- PROCEDURES
- OIA's
- MOS COMPATIBILITY TESTS
- TEST AND TRAINING

MSP'98 OPS TEAM INTERFACES



PROCESSES

- Standard MSOP Processes adapted to support MSP'98 with minor modifications
- Stored Sequence Process adapted to support long term (4-6 weeks) Housekeeping and short term Event Driven Sequences during Orbiter and Lander cruise phase
- Non-Stored Sequence Process adapted to support new type of command files, binary Files
  - INTERACTIVE FILE LOADS - IFL
  - NON-INTERACTIVE FILE LOADS - NIFL
- Flight System File Tracking and Management

Mars Surveyor Operations

MSOP STANDARD PROCESSES

	MGS	MCO	MPL
UPLINK PROCESS			
Stored Sequence Process	√		
Housekeeping sequences		√	√
Event Driven Sequences (JIT)		√	√
Non-interactive Payload Commands (NIPC)	√	**n/a**	**n/a**
Coordinated Commands	√	**n/a**	**n/a**
MOS-interactive Commands (MOSIC)	√	**n/a**	**n/a**
Spacecraft-interactive Commands (IC)	√	√	√
Express Commands	√	√	√
Pre- Approved Commands	√	√	√
Command Radiation	√	√	√
File Loads	**n/a**	√	√
DOWNLINK PROCESS			
Ground System Monitor Control and Configuration	√	√	√
Flight System Performance Analysis	√	√	√
Flight Systems Real time Health and Performance Assessment	√	√	√
Flight Systems Non Real Time Performance Analysis	√	√	√
Flight Systems Anomaly Planning, Analysis and Resolution	√	√	√
Navigation Analysis	√	√	√
Flight Software Maintenance	√	√	√
MISSION OPERATIONS ASSURANCE PROCESS			
Command Assurance Process	√	√	√
Anomaly Management	√	√	√
Configuration Management	√	√	√
Project Reporting	√	√	√
System Administration	√	√	√
Project Database Administration Process	√	√	√

Mars Surveyor Operations

PROCEDURES

- **Existing MSOP procedures adapted to include MSP'98 operations**

- **Few new procedures required**
  - **Nav - small forces file generation**
  - **MP&S - File load script adaptation**
  - **SCT - FSW updates, File Tracking**

- **Working procedures in place to support Test and Training, final versions completed after ORTs**

OPERATIONAL INTERFACE AGREEMENTS

- **MGS OIAs reviewed and reproduced with adaptations for MSP'98.**
  - **In place to support Test and Training, final versions completed after ORTs**

OIAs

							USERS				
				SOT							
PRODUCT NAME	OIA #	ORIGINATOR	MVACS	MARCI/MARDI	PMIRR	LIDAR	MP&S	NAV	SCT	DSN	DAA
SPICE Leap Second File	DAA-01	DAA	YES	YES	YES	YES		YES	YES		YES
E-KERNEL	DAA-02	DAA	YES	YES	YES	YES					
QQC SUMMARY REPORT	DAA-03	DAA	YES	YES	YES	YES			YES		
C-Kernel	DAA-04	DAA	YES	YES	YES	YES					
VIEW PERIODS	DSN-01	DSN	YES	YES	YES	YES	YES	YES	YES		
8-WEEK PLANNING FORECAST	DSN-02	DSN					YES				
7-DAY OPS SCHEDULE	DSN-03	DSN					YES	YES	YES		
INTER-CENTER VECTORS	DSN-04	DSN						YES			
ORBIT DATA FILES (ODF)	DSN-05	DSN						YES			
ASCII SPACECRAFT TRACKING DATA FILES	DSN-06	DSN						YES			
ARCHIVAL TRACKING DATA FILES (ATDF)	DSN-07	DSN						YES			
TRACKING STATION (DSS) LOCATIONS	DSN-08	DSN						YES			
WEATHER DATA	DSN-09	DSN						YES	YES		
EXTRA GALACTIC RADIO SOURCES (EGRS)	DSN-10	DSN						YES	YES		
UNIVERSAL TIME & POLAR MOTION (UTPM)FILE	DSN-11	DSN						YES	YES		
MEDIA CAL DATA FILES	DSN-12	DSN						YES			
DSS PASS LOGS/RECORDS ARCHIVE	DSN-13	DSN							YES		
RFI PREDICTS	DSN-15	DSN							YES		
DSN CONFIG CODES	DSN-16	DSN					YES		YES		
LIGHT TIME FILE	NAV-01	NAV	YES	YES	YES	YES	YES		YES	YES	YES
STATION POLYNOMIAL FILE (STATRJ)	NAV-02	NAV							YES	YES	
SPACECRAFT EPHEMERIS (P-FILE)	NAV-03	NAV								YES	
NAV TRIGS	NAV-04	NAV					YES				
OPTG	NAV-05	NAV	YES	YES	YES	YES	YES		YES		YES
SP KERNEL (SPK)	NAV-06	NAV	YES	YES	YES	YES	YES		YES		YES
PLANETARY CONSTANT FILE (PCK)	NAV-07	NAV	YES	YES	YES	YES	YES		YES		YES
MANEUVER PROFILE FILE (MPF)	NAV-08	NAV							YES		YES
ORBIT NUMBER FILE	NAV-09	NAV	YES	YES	YES	YES					YES
LANDER State & Covariance @ Entry Pt	NAV-10	NAV							YES		
PAYLOAD STATUS REPORT	SOT-01	SOT							YES		
MGS UHF HOUSEKEEPING DATA FOR '98 LANDER	SOT-02	SOT							YES		
MVACS SASF (ARF)	SOT-03	SOT					YES		YES		
MNVR PERFORMANCE DATA FILE (MPDF)	SCT-01	SCT						YES			
MNVR IMPLEMENTATION FILE (MIF)	SCT-02	SCT						YES			
SCT SYSTEM REPORT	SCT-03	SCT	YES	YES	YES	YES	YES	YES		YES	YES
ENGR CHANNEL PARAMETER UPDATE	SCT-05	SCT	YES	YES	YES	YES					
DECOM MAP UPDATES	SCT-06	SCT	YES	YES	YES	YES					
TELECOM TRIGS	SCT-08	SCT					YES				
AMD File (Orbiter)	SCT-09	SCT						YES			
Nav Engr Info File (NEIF)	SCT-10	SCT						YES			
TELECOM PERFORMANCE PREDICTS	SCT-13	SCT								YES	
SCLK-SCET COEFFICIENT FILE	SCT-14	SCT	YES	YES	YES	YES	YES				YES
S/C Model: Resource Envelope	SCT-17	SCT	YES				YES				
DUTY ROSTER / ON-CALL	SCT-015	SCT					YES	YES	YES		
REAL TIME OPS LOG	SCT-016	SCT					YES	YES	YES		YES
SASF	SEQ-01	ALL					YES		YES		
PEF	SEQ-02	SEQ	YES	YES	YES	YES		YES	YES		YES
SCMF	SEQ-05	SEQ							YES		YES
Command_DSN	SEQ-09	SEQ							YES/RTO		YES
SOE	SEQ-10	SEQ	YES	YES	YES	YES		YES	YES	YES	YES
SFOS	SEQ-11	SEQ	YES	YES	YES	YES		YES	YES	YES	YES
DKF	SEQ-13	SEQ						YES	YES	YES	
DSN ALLOCATION	SEQ-14	SEQ	YES	YES	YES	YES	YES	YES	YES		YES

MOS COMPATIBILITY

- Validates the interface between the GDS and the Flight Systems (Orbiter and Lander)

- So far, GDS uplink interface limited to partial verification with Flight Systems.
  - Exercised throughout the MST program at LMA

- Full Uplink system compatibility will be tested during KSC operations
  - Test Products will be generated using delivered Mission Builds

- Downlink system compatibility exercised with every MST
  - Routing, processing, broadcasting and querying data from the data base.
  - Interfaces with remote POCCs tested

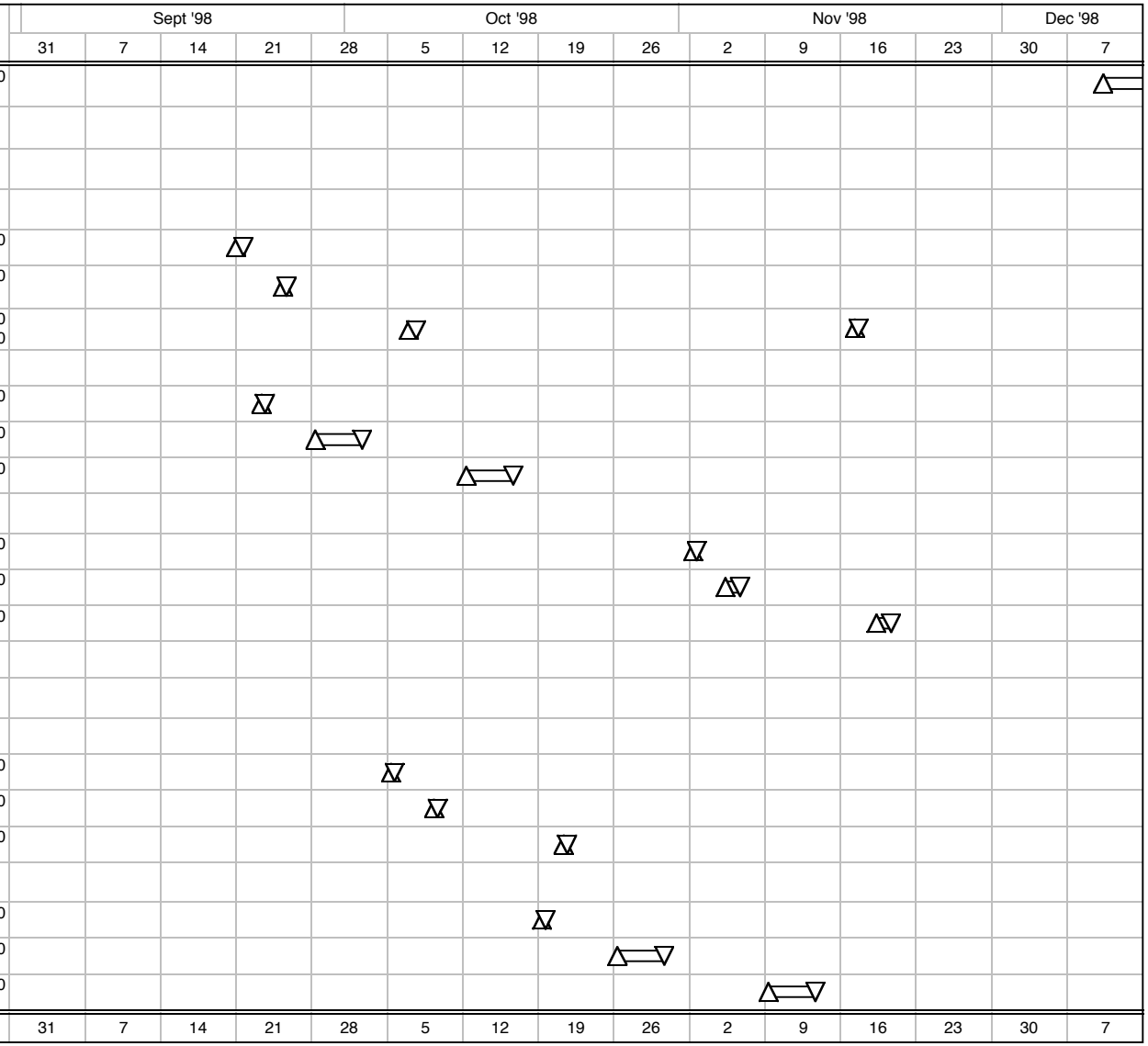
TEST AND TRAINING

- Starts shortly after the Flight Systems are shipped to KSC
- Completed prior to Orbiter Launch
- Training conducted simultaneously with MGS A/B Operations
- Emphasis on Launch and Initial Acquisition plus TCM/Cruise activities
  - Earth-Moon Cal ORT if schedule permits
- Plan consists of a Tabletop, Full Rehearsal and an Operational Readiness Test for each critical Mission Phase
  - Schedule permits some retests
- Test and Training for Planetary Operations scheduled for next summer

Mars Surveyor Operations

MSP'98 ORT SCHEDULE

Activity Name	Start Date	Finish Date	Duration
Orbiter Prime Launch Window	T12/10/98	T12/17/98	6.00
Ops Readiness Tests			
Orbiter ORTs			
Launch & Initial Acq			
Tabletop	M9/21/98	M9/21/98	1.00
Rehearsal	F9/25/98	F9/25/98	1.00
ORT	W10/07/98 T11/17/98	W10/07/98 T11/17/98	1.00 1.00
Cruise/TCM			
Tabletop	W9/23/98	W9/23/98	1.00
Rehearsal	M9/28/98	F10/02/98	5.00
ORT	M10/12/98	F10/16/98	5.00
EM Cal and Uhf Test			
Tabletop	M11/02/98	M11/02/98	1.00
Rehearsal	T11/05/98	F11/06/98	2.00
ORT	T11/19/98	F11/20/98	2.00
Lander ORTs			
Launch & Initial Acq			
Tabletop	M10/05/98	M10/05/98	1.00
Rehearsal	F10/09/98	F10/09/98	1.00
ORT	W10/21/98	W10/21/98	1.00
Cruise/TCM			
Tabletop	M10/19/98	M10/19/98	1.00
Rehearsal	M10/26/98	F10/30/98	5.00
ORT	M11/09/98	F11/13/98	5.00



Mission Support and Development

Open Items / Concerns

Issue	Resolution Plan	Expected Outcome
Completion of MOS compatabilty test objectives	1. MSOP continued support of MCO / MPL testing 2. Use of MSOP generated products and data flow paths for all KSC operations	Succesful completion of MOS compatibility testing prior to launch
Delayed completion of command dictionaries, block dictionaries and flight rules and constraints	1. Scheduled “launch final” sequence delivery 9/15/98 (MCO), 10/15/98 (MPL) 2. Post delivery updates processed with automated adaptation process	Completion of dictionaries and flight rules and constraints required for launch and early cruise
Maturity and completion of File Loading and Tracking (FLT) tool	1. Delivery scheduled for 9/1/98 2. Utilization of tool planned for ORT’S in late Sept / early Oct	Completion and validation of FLT prior to launch

Mission Support and Development

Open Items / Concerns (con't)

Issue	Resolution Plan	Expected Outcome
Delayed completion of Telecom Performance Analysis tool (part of SPAS)	1. MSOP support adaptation of MSAS Telecom tool for MSP'98 and Stardust to be supplied as GFP. 2. Dedicated engineer and managment assigned to preserve schedule 3. Interim status review scheduled for early October	Successful delivery of Telecom Analysis tool to meet MSP'98 and Stardust launch needs
Telemetry packet gaps / extra bit frames identified on MCO, MPL and SDU	1. Development project documenting the anomalies in a "flag" 2. STL being investigated as a tool to isolate the problem: (a) STL data being reviewed (b) Further investigation plan pending	Problem isolated and corrective action plan developed by 9/15

Mission Support and Development

Readiness Statement

With completion of the actions required to satisfy the open items / concerns, the operations and ground data systems will be ready to support MCO / MPL launch and early cruise